...o Library

Vol. 75 JANUARY-FEBRUARY, 19[illegible]

Bulletin

of the

Torrey Botanical Cl[illegible]

and

Torreya

CONTENTS

Fluorescing Substances in Roots ...
Bayard [illegible], Goodwin and Fred[illegible]

An Action Spectrum for Inhibition of the First Internode ... by Light ... *Dick[illegible] Goodwin and [illegible]*

A Physical Analysis of the Opening and Closing Movements ... Lobes of Venus' Flytrap ... *Otto [illegible]*

The Genetic Parameters ... of Resistance-Free ... Theory ... *[illegible]*

The Origin of Paleozoic ... the Calamite Type ... *Fred[illegible], Wolf and Fred[illegible]*

Plant Explorations in Guiana in 1[illegible], Chiefly to the ... Kaieteur Plateau—I ... *Ernest Hagen[illegible] and [illegible]*

Torreyana ...

Index to American Botanical Li[illegible] ...

Published by the Club bi-month[illegible]

[illegible] PRINTING CO[illegible]
[illegible]-COVER[illegible]
[illegible]-PENNSYLVANIA

THE TORREY BOTANICAL CLUB

Officers for 1947

President: Ghoech H. Shull

Vice-presidents: Rutherford Platt, Norma E. Pfeiffer

Recording Secretary: Libero Ajello

Corresponding Secretary: Jennie L. S. Simpson

Treasurer: Elva Lawton

Editor: Harold W. Rickett

Business Manager: Harold H. Clum

Bibliographer: Mrs. Lazella Schwantes

The Bulletin of the Torrey Botanical Club

and Torreya

Editor

Harold W. Rickett

Associate Editors

Irving W. Bailey — Adriance S. Foster
Stanley A. Cain — Henry Allan Gleason
M. A. Chrysler — John W. Shive
W. H. Camp

for Torreya

Harold H. Clum — Libero Ajello

Subscriptions, dues and inquiries about back numbers should be sent to the office of publication, N. Queen St. and McGovern Ave., Lancaster, Pa., or to Dr. Elva Lawton, Hunter College, New York 21, N. Y. Correspondence about advertisements and circulation should be addressed to Dr. H. H. Clum, Hunter College, New York 21, N. Y. Communications about exchanges should be sent to Dr. Jennie L. S. Simpson, Hunter College, New York 21, N. Y. Manuscripts intended for the Bulletin should be sent to Dr. H. W. Rickett, The New York Botanical Garden, New York 58, N. Y. Short notes for Torreya may be addressed to Dr. H. H. Clum, Hunter College, New York 21, N. Y.

Claims for missing numbers must be made within 60 days from the date of issue.

The subscription price of the Bulletin of the Torrey Botanical Club (including Torreya) is $7.00 a year except to active members of the Club. Of the annual membership dues, $3.50 covers a year's subscription to the Bulletin.

Entered as second-class matter October 8, 1949 at the post office at Lancaster, Pa., under the Act of March 3, 1879. Accepted for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph 4, section 412, P. L. & R.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, NO. 1, PP. 1–17 JANUARY, 1948

FLUORESCING SUBSTANCES IN ROOTS

RICHARD H. GOODWIN AND FREDERICK KAVANAGH[1]

Blue and yellow fluorescing materials have been previously reported from the roots of legumes (Linsbauer 1929). In the course of an investigation of the inhibition of the first internode of *Avena sativa* by light (Goodwin 1941) it was observed that a bright blue fluorescence was excited in the roots of the experimental plants by ultra-violet light (the 3650 Å line from a 100-watt G. E. type H4 mercury arc lamp screened with Corning Nos. 5860 and 738 glass filters).

The nature of the fluorescent material has been investigated. Preliminary studies in 1942 showed that it could be extracted from *Avena* roots with n-butanol. The material in the extract could not be identified with pure thiochrome; first, because of its slower photodecomposition in ultra-violet light, and second, because its fluorescent spectrum showed a higher intensity in the blue-green than that of thiochrome.[2]

In the present paper the authors wish, first, to record some observations on the occurrence of fluorescing substances in the roots of different species of plants, and second, to report some of the properties of these substances, which have been extracted from the roots of several species, but particularly from *Avena*.

The Occurrence of Fluorescing Substances in the Roots of Plants. In order to ascertain the occurrence of fluorescing compounds in the roots of higher plants, the roots of 135 species belonging to 126 genera and 69 families were examined in ultra-violet light from an AH–4 Mazda mercury arc lamp shielded with a Corning No. 5860 glass filter. For each species a subjective judgment was made of the color and intensity of the fluorescence. The results of this survey are recorded in table 1.

The roots of all but six species examined were definitely fluorescent. The exceptions were ferns with blackish pigment in the roots; but acetone extracts of the roots of three of these species and the rhizomes of two others were brightly fluorescent. The most common color of the fluorescence was

[1] The cost of publishing table 1 has been partly defrayed by a grant from Connecticut College.

[2] The fluorescent spectra of quinine, thiochrome, and the fluorescent material from *Avena* roots were photographed with a Bausch and Lomb quartz spectrograph. The densities of the plates were then determined on a recording photo-electric densitometer. The authors are indebted to Dr. L. T. Steadman of the Division of Radiology, School of Medicine and Dentistry, the University of Rochester, for use of the spectrograph, and to Dr. Fred Perrin of Eastman Kodak Company for determining the density of the spectrographs on the densitometer.

[THE BULLETIN for November–December (74: 443–541) was issued December 3, 1947.]

TABLE 1. *A taxonomic survey of fluorescence in roots.*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Lycopodiaceae				
Lycopodium complanatum L. var. *flabelliforme* Fern.	3	bluish-white	+	rhizome bluish-white (++)
L. obscurum L.	3	bluish-white	+	
Selaginellaceae				
Selaginella Kraussiana A. Br.	2	bluish	++	
Equisetaceae				
Equisetum arvense L.	3	bluish-white	++	
Schizaeaceae				
Anemia Phyllitidis Swartz	2	none	roots dark	
Polypodiaceae				
Cyrtomium falcatum J. Smith	2	greenish-white	++	
Dennstaedtia punctilobula (Michx.) Moore	3	none	roots dark	acetone extract showed a bright greenish-white fluorescence
Dryopteris noveboracensis (L.) A. Gray	3	none	roots dark	rhizome greenish-white (+++)
Onoclea sensibilis L.	3	none	roots dark	rhizome parenchyma purplish (+++), vascular bundles bluish-white (+++)
Polystichum acrostichoides (Michx.) Schott.	3	none	roots dark	acetone extract showed a bright greenish fluorescence
Pteridium latiusculum (Desv.) Hieron.	3	none	roots dark	acetone extract with orange color and greenish fluorescence
Cycadaceae				
Zamia floridana DC.	2	blue	+++	root tubercles with bright red zone caused by chlorophyll fluorescence of blue-green algae
Taxaceae				
Taxus canadensis Marsh	3	bluish-white	++	
Pinaceae				
Juniperus virginiana L.	3	bluish	++	
Pinus Strobus L.	3	bluish	++	
Tsuga canadensis (L.) Carr	3	bluish	+++	

TABLE 1.—*Continued*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Pandanaceae				
Pandanus Veitchii Hort.	2	bluish-green	+	aerial roots with bluish stele and red (chlorophyll fluorescence) cortex
Sparganiaceae				
Sparganium eurycarpum Engelm.	3	blue	+++	
Gramineae				
Agrostis palustris Huds.	1	blue	+++	brightest at root tip
A. tenuis Sibth.	1, 4	blue	+++	
Arrhenatherum elatius (L.) Mert. & Koch.	1, 4	blue	+++	
Arundinaria falcata Nees.	2	bluish	++	
Avena sativa L. (Victory)	1	blue	++++	
Bromus inermis Leyss.	1, 4	blue	+++	
Dactylis glomerata L.	1, 4	blue	+++	
Festuca elatior L.	1, 4	blue	+++	
F. rubra L. var. *commutata* Gand.	1	greenish	+++	
Hordeum vulgare L. (Wisconsin No. 38)	1, 4	blue	++++	brightest at root tip
Lolium perenne L.	1	bluish	+++	
Phleum pratense L.	1, 4	blue	++++	
Phyllostachys Castillonis Hort.	2	bluish	+++	
Poa compressa L.	1, 4	blue	+++	
P. pratensis L.	1	blue	+++	
P. trivialis L.	1, 4	blue	+++	
Secale cereale L.	1, 4	blue	+++	
Sorghum vulgare Pers. (Sudan grass)	1, 4	blue	++++	
Triticum sp. (Leaps prolific)	1, 4	blue	++++	
Zea mays L.	1	blue	++++	more whitish at root tip
Cyperaceae				
Carex vulpinoidea Michx.	3	blue	+++	
Cyperus alternifolius L.	2	blue	+++	stele brightly fluorescent; cortex dark
Araceae				
Anthurium Andraeanum Lind.	2	bluish-white	++	
Philodendron scandens C. Koch & H. Sello	2	bluish	+++	

TABLE 1.—*Continued*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Commelinaceae				
Rhoco discolor Hance	2	bluish	+++	whitish at root tip
Tradescantia reflexa Raf.	2	bluish	++++	
Liliaceae				
Allium Cepa L.	3	bluish	+++	
Dracaena fragrans L. var. *Massangeana* Hort.	2	blue	+++	stele brightly fluorescent; cortex fainter and more whitish
Maianthemum canadense Desf.	3	bluish	+++	
Smilax glauca Walt.	3	bluish	++	rhizome bluish-white (+++)
Iridaceae				
Iris sp.[c]	2	whitish	++	
Marica caerulea Ker.	2	greenish	++	
Sisyrinchium graminoides Bickn.	3	bluish-white	++	
Marantaceae				
Maranta leuconeura Morr.	2	bluish	+++	
Orchidaceae				
Cypripedium acaule Ait.	3	bluish	+++	
Piperaceae				
Peperomia obtusifolia A. Dietr.	2	bluish	+	
Betulaceae				
Betula lenta L.	2	bluish	++	
Ulmaceae				
Celtis occidentalis L.	2	bluish	++	
Urticaceae				
Pellionia Daveauana N. E. Br.	2	bluish-white	++	
Polygonaceae				
Rumex Acetosella L.	3	blue	+++	reddish fluorescence in brown-stained cortex
Chenopodiaceae				
Chenopodium sp.[c]	3	blue	++++	
Caryophyllaceae				
Dianthus Caryophyllus L.	1	bluish-purple	++	
Stellaria media (L.) Cyrill.	3	blue	+++	

TABLE 1.—*Continued*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Ranunculaceae				
Aquilegia sp.[c]	2	bluish	++	
Delphinium Ajacis L.	2	greenish-white	++	
Ranunculus bulbosus L.	3	bluish	+++	bulb also bluish
Berberidaceae				
Berberis Thunbergii DC.	3	greenish-yellow	++++	
Lauraceae				
Benzoin aestivale (L.) Nees	2	bluish	++	
Cruciferae				
Alyssum maritimum Lam.	1	blue	++	
Brassica oleracea L. (Broccoli)	1	bluish-white	+++	
Iberis amara L.	1	bluish-white	++	
Raphanus sativus L.	1	bluish-white	+++	
Crassulaceae				
Kalanchoë verticillata Elliott (= *K. tubiflora*)	2	bluish	++	
Saxifragaceae				
Saxifraga saramentosa L.	2	bluish-white	+	
Rosaceae				
Fragaria sp. (Cult. Everbearing)	3	bluish-white	++	
Potentilla simplex Michx. var. *typica* Fern.	3	bluish	++	
Leguminosae[d]				
Glycine Max (L.) Merr. (*Biloxi*)	1	bluish	+++	
Lathyrus odoratus L.	1	whitish	++	
Lespedeza capitata Michx.	3	bluish	+++	nodules bright bluish
Lupinus perennis L.	1	whitish	+	red at root tip
L. perennis L.	2	whitish	+	nodules greenish
Mimosa pudica L.	1	whitish	++	
Phascolus aureus Roxbg. (Mung bean)	1	purplish	+	whitish at root tip
Pisum sativum L. (Little Marvel)	1	white	++++	
Trifolium hybridum L.	3	bluish	++	
Oxalidaceae				
Oxalis europaea Jordan	3	blue	+++	

TABLE 1.—*Continued*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Geraniaceae				
Pelargonium domesticum	2	whitish	++	
Tropaeolaceae				
Tropaeolum majus L.	2	bluish-white	+++	subterranean portion of stem greenish
Rutaceae				
Citrus sinensis Osbeck	2	blue	+++	
Simarubaceae				
Ailanthus altissima (Mill.) Swingle	3	bluish	+++	present in cortex and stele of roots over 1 cm. diameter
Polygalaceae				
Polygala polygama Walt.	3	blue	+++	subterranean runners and cleistogamous flowers bright blue
Euphorbiaceae				
Euphorbia splendens Bojer	2	bluish-white	+++	
Buxaceae				
Pachysandra terminalis Sieb. & Zucc.	3	blue-greenish-white	+++	
Anacardiaceae				
Rhus copallina L.	3	blue	+++	whitish stele
Aquifoliaceae				
Ilex glabra (L.) Gray	2	bluish	++	
Celastraceae				
Celastrus scandens L.	3	blue	+++	
Aceraceae				
Acer Negundo L.	3	blue	+++	
Balsaminaceae				
Impatiens biflora Walt.	3	bluish	++	
Vitaceae				
Vitis aestivalis Michx.	3	blue	+++	
Malvaceae				
Hibiscus Rosa-sinensis L.	2	bluish	+++	
Violaceae				
Viola papilionacea Pursh.	3	blue	++++	
V. tricolor L. (Pansy)	2	blue	++++	about the brightest fluorescence observed

TABLE 1.—*Continued*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Passifloraceae				
Passiflora alato-caerulea **Lindl.**	2	greenish-white	+++	
Cactaceae				
Zygocactus truncatus **Schum.**	2	bluish-white	+++	
Onagraceae				
Fuchsia speciosa **Hort.**	2	bluish-white	+	
Araliaceae				
Aralia nudicaulis **L.**	3	bluish	++	
Umbelliferae				
Apium graveolens **L. var. *dulce* DC.**	2	bluish	++	
Daucus Carota **L. var. *sativa* DC.**	1	bluish-green	+++	
Cornaceae				
Cornus florida **L.**	3	bluish	++++	
Ericaceae				
Kalmia latifolia **L.**	2	bluish	+	
Monotropa Hypopitys **L.**	3	bluish	+	
M. uniflora **L.**	3	blue	++	stems bluish (+++)
Primulaceae				
Lysimachia quadrifolia **L.**	3	bluish	+	rhizomes bluish
Styracaceae				
Styrax americana **Lam.**	2	bluish	++	very bright bluish hypocotyl
Oleaceae				
Fraxinus pennsylvanica **Marsh.**	3	bluish	++	
Asclepiadaceae				
Stapelia variegata **L.**	2	bluish	+++	
Boraginaceae				
Cynoglossum grande **Douglas**	1	greenish	+++	
Labiatae				
Coleus Blumei **Benth.**	2	bluish-white	++	
Solanaceae				
Datura Stramonium **L.**	1	bluish-white	++++	hypocotyl white
Lycopersicon esculentum **Mill. (Rutgers)**	1	purplish	++	whitish at root tip
Petunia hybrida **Vilm.**	1	bluish	+++	
Solanum tuberosum **L.**	—	.....	.....	tuber bluish (++)

TABLE 1.—*Continued*

Species	Source of material[a]	Nature of fluorescence		
		Color	Intensity[b]	Remarks
Scrophulariaceae				
Antirrhinum majus L.	1	bluish	++	
Melampyrum lineare Lam.	3	blue	+++	
Plantaginaceae				
Plantago lanceolata L.	3	blue	+++	
P. major L.	3	blue	+++	
Caprifoliaceae				
Sambucus canadensis L.	3	bluish-white	++	
Campanulaceae				
Campanula ramosissima Sibth. & Sm.	2	blue	+++	
Lobeliaceae				
Lobelia Erinus L.	2	greenish-white	+++	
Compositae				
Ageratum Houstonianum Mill.	1	whitish	++	
Ambrosia artemisiifolia L.	3	bluish	++	
Calendula officinalis L.	1	whitish	++	
Centaurea Cyanus L.	1	bluish-white	++	
Galinsoga ciliata (Raf.) Blake	3	bluish-white	++	
Helianthus annuus L.	1	bluish-white	++	
Lactuca sativa L.	1	bluish-purple	+	
Solidago rugosa Mill.	3	bluish-white	++	subterranean rhizomes bluish
S. sempervirens L. var. *mexicana* (L.) Fern.	2	bluish	+	

[a] Numbers in this column refer to sources as follows:
1: roots from seedlings growing in Petri dishes on filter paper; germinated in the laboratory at room temperature.
2: roots from plants growing in the greenhouse.
3: roots from plants growing outdoors.
4: seeds obtained through the courtesy of Peter Henderson & Co.

[b] Intensity indicated as follows: weak (+), fairly bright (++), bright (+++), very bright (++++).

[c] Species not identified because of immature condition.

[d] Legume roots without nodules unless otherwise indicated.

blue, bluish, or bluish-white (109 species). The roots of 11 species were greenish, those of *Berberis Thunbergii* having a brilliant greenish-yellow fluorescence; those of eight others were almost white. Linsbauer (1929) reported a bright yellow fluorescence in *Pisum* and a weak yellow fluorescence in *Lens*, but this color was not observed in the legumes listed here. A red fluorescence was observed in the root tips of young, dark-grown seedlings of *Lupinus perennis* and in necrotic tissue around cavities in galls on roots of this species, and in the brownish cortex of the tap root of *Rumex Acetosella*. There was no sign of green pigment in the above-mentioned tissues and the red fluorescence was probably not due to the presence of chlorophyll. Greenish aërial roots such as those of *Pandanus Veitchii*, on the other hand, showed a red chlorophyll fluorescence, as did the root tubercles of *Zamia floridana* in the zones invaded by blue-green algae.

Fluorescence was particularly bright in the roots of oats (*Avena sativa*) and in those of the pansy (*Viola tricolor*).

When the species are considered taxonomically, all but one of the *Gramineae* exhibited a bright blue fluorescence, while the *Leguminosae* and *Compositae* seemed to have substances exhibiting a white or whitish fluorescence predominating.

One may conclude from these observations that fluorescing substances have a wide distribution in the roots of vascular plants. The differences in color of the fluorescence in the various species examined suggest that a number of compounds must be responsible for the fluorescence. Mixtures of blue-, green-, and white-fluorescing compounds could account for all of the colors observed with the exception of the yellows and reds.

Extraction of the Fluorescing Material. The fluorescent substances may be readily extracted from roots by various solvents such as n-butanol and aqueous acetone. Table 2 shows the results obtained by extracting the roots of six different species of Angiosperm seedlings. The seeds were germinated in Petri dishes on filter paper, or those of *Pisum* in pots of sand. The roots were removed and ground in a mortar with several changes of solvent. Each extract was centrifuged and decanted from the cellular debris. The solvent was then evaporated to a convenient volume, and the residual extract diluted with water or with 50 per cent aqueous ethanol to give a concentration five times that to be tested fluorometrically. One ml. of this diluted extract was placed in a cylindrical, calibrated cuvette 13 mm. in diameter and buffer solution added to the 5 ml. mark. The fluorescence was measured on a Klett fluorimeter-colorimeter,[3] an instrument designed and described by Kavanagh (1941). The fluorescence standard was a solution of 1 mg. quinine sulfate per liter 0.1 N H_2SO_4. Lamp filters were Corning No. 5970 and photocell filters, Corning No. 3389 for both standard and unknown.

[3] This instrument was purchased with a grant to the senior author from the Rumford Committee of the American Academy of Arts and Sciences.

TABLE 2. *Fluorescent activity of raw extracts of roots.*

Species	Age of seedlings in days	Number of seedlings extracted	Extracting solvent	pH giving maximum fluorescence	Number of plants giving fluorescence equivalent to 1 mg. quinine/liter
Avena sativa No. 1	4	60	n-butanol	9.0	1.0
" " No. 5	3	1,620	"	8.2	0.6
" " No. 7	4	220	acetone	9.0	0.5
" " No. 8	3	200	"	8.0	0.6
" " No. 13	4	250	"	9.0	0.3
Hordeum vulgare	4	50	n-butanol	10.9	25
" "	4	500	"	9.1	18
Phleum pratense	5	ca. 8,000	"	10.9	ca. 3,400
" "	5	ca. 28,000	"	9.1	ca. 3,500
Triticum sp.	4	50	"	9.5	26
" "	4	500	"	9.1	31
Pisum sativum	7	18	"	8.2	2.8
Lycopersicon esculentum (red pear)	9	120	"	10.9	74
" " (Rutgers)	7	700	"	10.8	344

TABLE 3. *A comparison of the properties of three fluorescing fractions of Avena root extracts.*

Fraction A	Fraction B	Fraction C
Soluble in water, 95% aqueous ethanol, n-butanol, chloroform, aqueous acetone	Soluble in water, 95% aqueous ethanol, n-butanol, chloroform, dry acetone, dry benzene	Soluble in water, 95% aqueous ethanol, n-butanol, chloroform
Insoluble (or nearly so) in dry acetone, dry benzene and petroleum ether	Insoluble in petroleum ether	Insoluble in petroleum ether
Adsorption on powdered alumina strong	Adsorption on powdered alumina weak	Adsorption on powdered alumina intermediate between that of fractions A and B
Fluorescence bright blue; intensity decreasing sharply at pH values below 3 to about 10% of that at the higher pH values	Fluorescence greenish in alkaline and bluish in acid solution; intensity decreasing between pH 9 to 5	Fluorescence bright blue; intensity not showing marked change with change of pH
Extracted from chloroform by dilute HCl	Not so effectively extracted from chloroform by dilute HCl	Extracted from chloroform by dilute HCl
Partially precipitated from acid solution when the solution is extracted with chloroform. This step must apparently be preceded by repeated shaking of the aqueous extract with benzene	Not precipitated from acid solution when the solution is extracted with chloroform	Not precipitated from acid solution when the solution is extracted with chloroform

The buffers used were McIlvaine's citric acid—disodium phosphate buffers as given in the *Handbook of Chemistry and Physics*, except for pH values 1.4, 2, 9, 10, and 11.3. The pH 1.4 solution was obtained with 0.1 N H_2SO_4; the pH 2 buffer was made by adding 2 ml. 2 N H_2SO_4 to 100 ml. 0.1 M citric acid; the pH 11.3 buffer was 0.2 M Na_2CO_3; the pH 9 and 10 buffers were made by mixing 0.2 M Na_2CO_3 and 0.2 M Na_2HPO_4. The pH of the extract-buffer mixtures were usually tested immediately after the fluorescence determinations on a Leeds & Northrup pH meter (a Beckman high pH electrode was used to measure pH 11.3), and in no case had the pH of the original buffer solution been changed by more than 0.2 pH unit. The measured pH of the mixture is always the one here reported.

Each extract was tested in a complete series of 10–13 different buffers. The values for each extract given in table 2 are maximum values obtained for the buffer series, and the pH at which each maximum was obtained is given. No data are available for comparison of fluorescence in terms of weight of tissue extracted. However, *Avena*, *Hordeum*, and *Triticum* had root systems of comparable size per plant, while *Pisum* had a larger root system per plant than the cereals, and *Lycopersicon* a somewhat smaller one. *Phleum* seedlings had a single, very fine, thread-like root; at least 100 to 200 of these were probably equivalent to the root system of one *Avena* seedling. On this basis, it can be seen that *Avena* is by far the richest source of fluorescing substances of the six species extracted.

The Fluorescence of the Extracts as a Function of pH. The fluorescence of organic compounds usually varies markedly with the hydrogen ion concentration of the solute. The shapes of the pH-fluorescence curves for a number of pure compounds have been found to be very characteristic (Ellinger & Holden 1944; Huff 1947; Kavanagh & Goodwin in press). Hence, the shapes of the pH–fluorescence curves for extracts are of interest as suggesting the possible nature of the predominating fluorescent substances in the extracts. Differences in the shapes of such curves would indicate differences in the fluorescing substances present.

For each extract tested, the relative fluorescence in the buffer series was calculated as a percentage of the maximum fluorescence obtained. The pH-fluorescence curves for an extract from the roots of each species listed in table 2 are shown in figure 1. The curves for *Hordeum*, *Triticum*, *Phleum*,

Explanation of figures 1 and 2

Fig. 1. The relationship between relative fluorescence and pH for n-butanol extracts of the roots of six different species of Angiosperms, *Avena sativa*, *Hordeum vulgare*, *Triticum* sp. (Leaps prolific), *Phleum pratense*, *Pisum sativum*, and *Lycopersicon esculentum*. FIG. 2. The relationship between relative fluorescence and pH for acetone extracts of the roots of three different species of ferns, *Polystichum acrostichoides*, *Pteridium latiusculum*, and *Dennstaedtia punctilobula*.

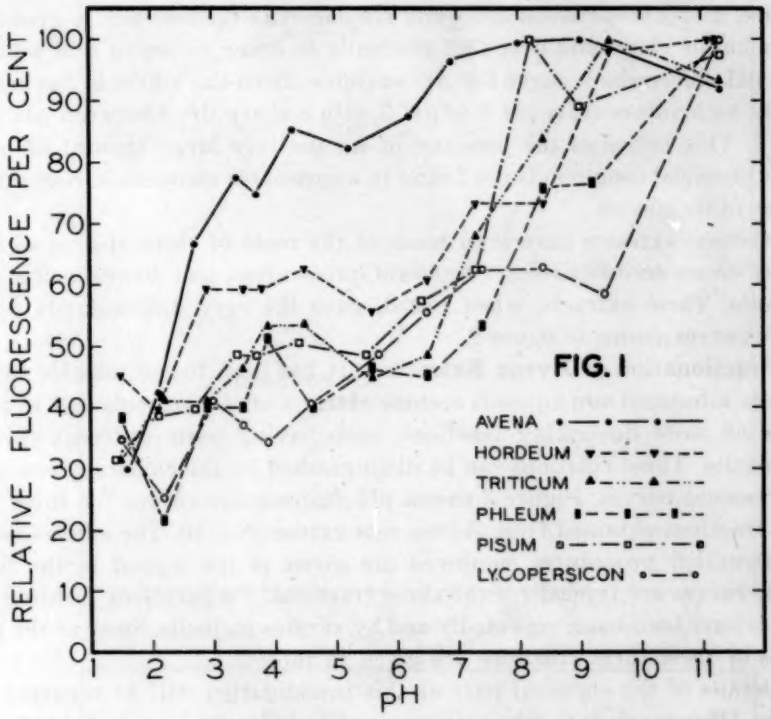

RELATIVE FLUORESCENCE PER CENT
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
pH
AVENA
HORDEUM
TRITICUM
PHLEUM
PISUM
LYCOPERSICON

FIG. 1

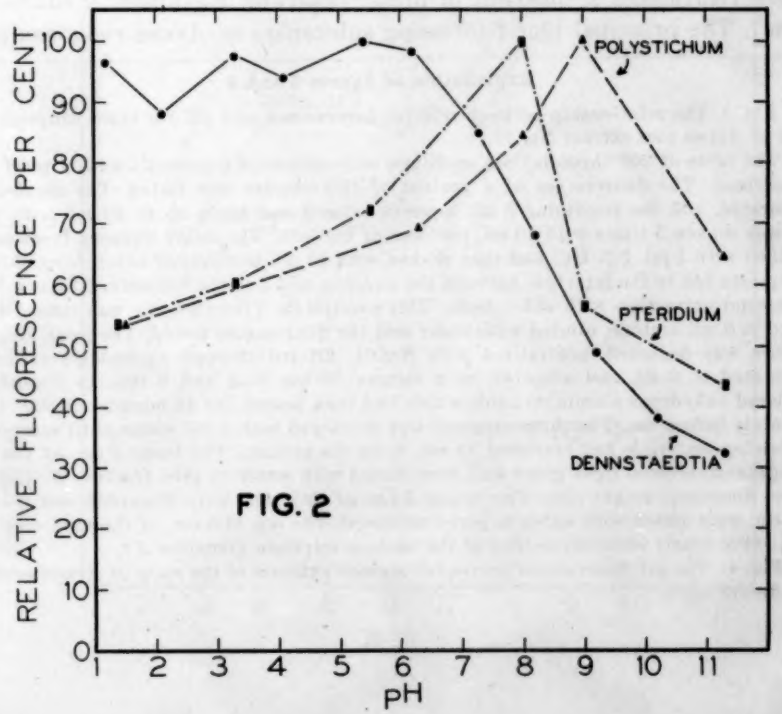

RELATIVE FLUORESCENCE PER CENT
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
pH
POLYSTICHUM
PTERIDIUM
DENNSTAEDTIA

FIG. 2

Pisum, and *Lycopersicon* are quite similar. The fluorescence is greatest in the alkaline range and drops off gradually to lower values in acid solutions. The pH–fluorescence curve for *Avena* differs from the others in having relatively high values from pH 8 to pH 3 with a sharp drop between pH 3 and pH 2. This indicates the presence of a relatively large amount of one or more chemical compounds not found in appreciable amounts in root extracts of the other species.

Acetone extracts have been made of the roots of three species of ferns, *Polystichum acrostichoides*, *Pteridium latiusculum*, and *Dennstaedtia punctilobula*. These extracts, when tested, gave the very different pH–fluorescence curves shown in figure 2.

Fractionation of Avena Extracts. It has been found possible to fractionate n-butanol and aqueous acetone extracts of *Avena* roots and to obtain three or more fluorescing fractions, each having quite different chemical properties. These fractions can be distinguished by their characteristic pH–fluorescence curves. Figure 3 shows pH–fluorescence curves for three separate fractions obtained from *Avena* root extract No. 10. The extraction and fractionation procedures employed are given in the legend to the figure. These curves are typical for the three fractions. Preparations yielding such curves have been made repeatedly and by various methods. Some of the properties of these three fractions are given in table 3.

Details of the chemical part of this investigation will be reported elsewhere (Kavanagh & Goodwin in press; Goodwin, Kavanagh & Stafford in press). The principal blue-fluorescing substances in *Avena* roots cannot be

Explanation of figures 3 and 4

FIG. 3. The relationship between relative fluorescence and pH for three different fractions of *Avena* root extract No. 10.

The roots of 200 three-day-old seedlings were extracted repeatedly with a total of 50 ml. acetone. The fluorescence of a portion of this extract was tested. The acetone was evaporated, and the remaining 3 ml. aqueous extract was made up to 10 ml. with water and was shaken 5 times with 10 ml. portions of benzene. The milky aqueous fraction was acidified with 1 ml. 1 N HCl and then shaken with 10 ml. portions of chloroform. A white precipitate fell to the interface between the aqueous acid and the chloroform layers during the second extraction with chloroform. This precipitate (*fraction A*) was removed, dissolved in 5 ml. acetone, diluted with water and the fluorescence tested. The remaining acid solution was decanted, neutralized with NaOH, filtered through a small pyrex funnel, evaporated to 2 ml. and adsorbed on a column 50 cm. long and 6 mm. in diameter of powdered anhydrous aluminum oxide which had been heated for 30 minutes at 300° C. immediately before use. The chromatogram was developed with 3 ml. water until some of the fluorescing materials had travelled 32 cm. down the column. The basal 3 cm. of the chromatogram fluoresced light green and were eluted with water to give *fraction B*. The next 26 cm. fluoresced bright blue. The lowest 3 cm. of this zone were discarded and the next 11.5 cm. were eluted with water to give *fraction C*. The top 11.5 cm. of the blue zone gave a pH curve nearly identical to that of the white precipitate (*fraction A*).

FIG. 4. The pH-fluorescence curves for acetone extracts of the roots of *Avena* seedlings of different ages.

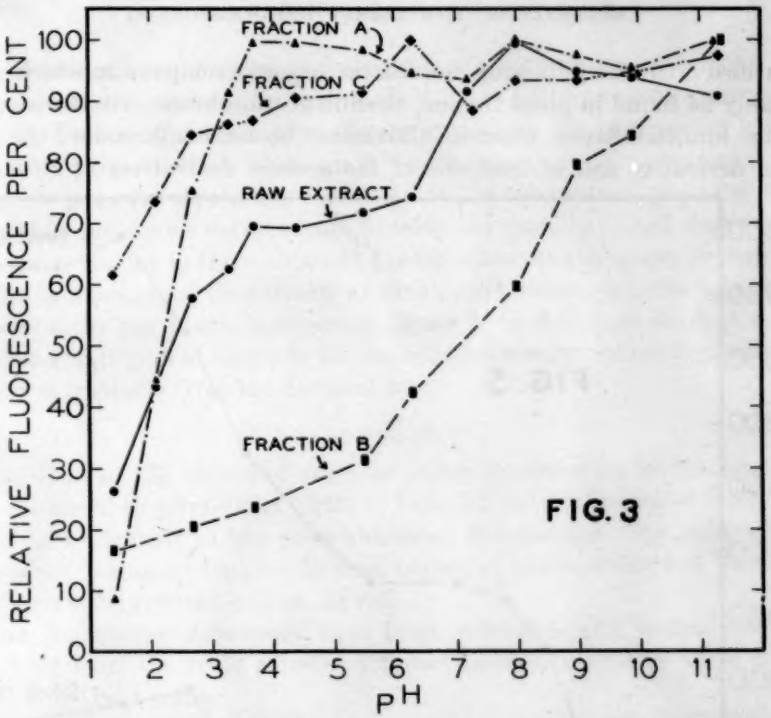

FRACTION A
FRACTION C
RAW EXTRACT
FRACTION B
RELATIVE FLUORESCENCE PER CENT
pH

FIG. 3

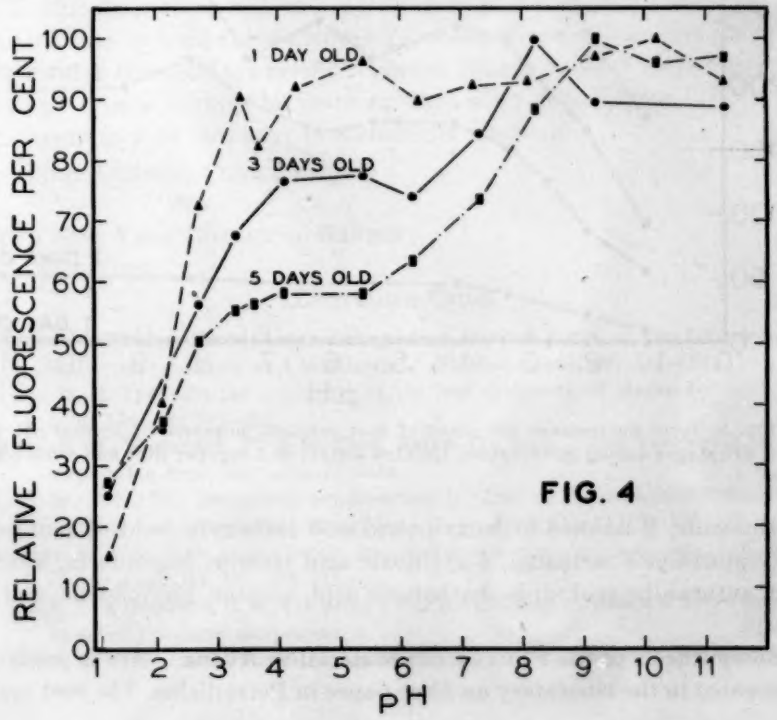

1 DAY OLD
3 DAYS OLD
5 DAYS OLD
RELATIVE FLUORESCENCE PER CENT
pH

FIG. 4

identified with the following fluorescent organic compounds which might possibly be found in plant tissues: vitamin A, thiochrome, riboflavin, glucoflavin, lumilactoflavin, gluco-iso-alloxazine, bis-imino-alloxazine, the n-butanol derivative and at least one of the acetone derivatives of N^1-methyl-

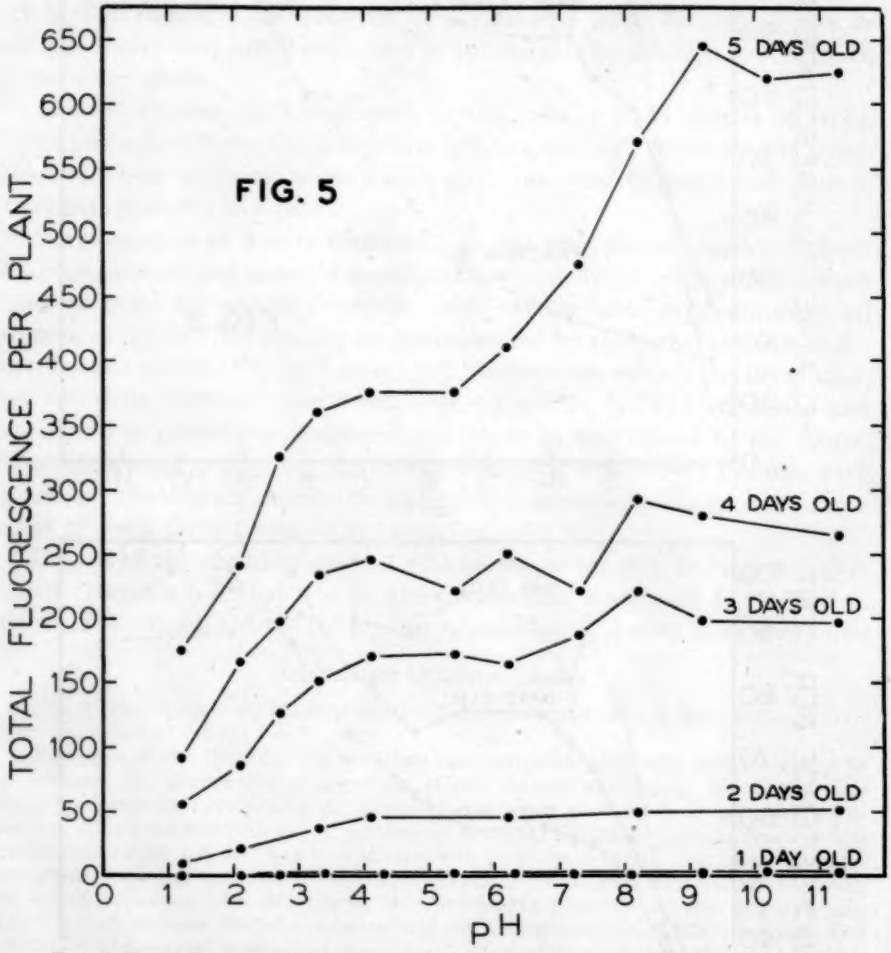


FIG. 5. Total fluorescence per plant of root extracts measured at several pH values and at five stages during germination. Quinine sulfate at 1 mg. per liter had a fluorescence of 100.

nicotinamide, 2-amino-4-hydroxy-pteridine-6-carboxylic acid, 2-amino-4-hydroxy-pteridine-6-methanol, 4-pyridoxic acid lactone, leucopterin, xanthopterin, anthranilic acid, di-iso-barbaturic acid, quinine, phytofluene, and terthienyl.

Biosynthesis of the Fluorescent Material in Avena. *Avena* seeds were germinated in the laboratory on filter paper in Petri dishes. The root systems

of the seedlings were sampled at daily intervals, extracted with acetone, and the fluorescence measured. An examination of the pH-fluorescence curves for extracts of roots of various ages (figure 4) reveals the presence of a relatively high proportion of "fraction A" in the one-day-old roots, and a progressively larger proportion of "fraction B" in the roots of the older seedlings. Thus the *Avena* extract from five-day-old roots has a pH-fluorescence curve quite similar to those obtained for the other species shown in figure 1.

The fluorescence of the extracts at various pH values, expressed as potentiometer units per plant, is shown in figure 5. In five days there is a two-hundred-and-fifty-fold increase in the blue-flouresecing substances over the amount extractable from the dormant seed.

SUMMARY

The roots of 135 species of vascular plants representing 69 families have been examined in ultra-violet light; of these all but six species of ferns with much dark pigment in the roots exhibited fluorescence. The color of the fluorescence was most frequently blue, bluish, or bluish-white, but was sometimes greenish, greenish-yellow, or red.

The fluorescing substances have been extracted with acetone or with n-butanol from the roots of nine different species, including three of the above-mentioned ferns.

The blue-fluorescing material extracted from *Avena sativa* roots has been separated into at least three distinct fractions. Some of the chemical properties of these fractions are briefly reported. Biosynthesis of these fluorescing substances occurs during the first few days after germination.

DEPARTMENT OF BOTANY, CONNECTICUT COLLEGE
NEW LONDON, CONNECTICUT
AND
THE NEW YORK BOTANICAL GARDEN
NEW YORK

Literature Cited

Ellinger, P. & Holden, M. 1944. Quenching effect of electrolytes on the fluorescence intensity of riboflavin and thiochrome. Biochem. Jour. **38**: 147–150.

Goodwin, R. H. 1941. On the inhibition of the first internode of *Avena* by light. Am. Jour. Bot. **28**: 325–332.

Goodwin, R. H., Kavanagh, F., & Stafford, Helen. [In press.] Blue fluorescing fractions extractable from the roots of oats.

Huff, J. W. 1947. The fluorescent condensation product of N^1-methylnicotinamide and acetone. I. Synthesis and properties. Jour. Biol. Chem. **167**: 151–156.

Kavanagh, F. 1941. New photoelectric fluorimeter and some applications. Ind. & Eng. Chem. Anal. Ed. **13**: 108–111.

Kavanagh, F. & Goodwin, R. H. [In press.] The relationship between pH and fluorescence of several organic compounds.

Linsbauer, L. 1929. Über Fluoreszenzerscheinungen an Wurzeln. Bot. Archiv. **23**: 441–444.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, NO. 1, PP. 18–21 JANUARY, 1948

AN ACTION SPECTRUM FOR INHIBITION OF THE FIRST INTERNODE OF AVENA BY LIGHT

RICHARD H. GOODWIN AND OLGA V. H. OWENS

Various physiological processes are profoundly affected by radiant energy. This energy must be absorbed before it can have a photochemical effect. In many cases specific chemical compounds are responsible for this absorption. Information concerning the nature of the absorption spectrum of a compound of this sort can be secured by determining the action spectrum of the particular phenomenon under consideration, that is, the relationship between the reciprocal of the amount of monochromatic radiant energy required to produce a constant physiological effect and the wave-length. An action spectrum may differ from the absorption spectrum of the active compound for various reasons, one of them being the presence in the tissues of interfering pigments.

A number of investigations on the effectiveness of various regions of the spectrum in inhibiting elongation of the first internode of *Avena* seedlings have shown that red light is most effective in bringing about such inhibition (2, 3, 5, 7, 10, 11). The most light-sensitive phase of this inhibition is due primarily to a reduction in the number of cell divisions in the internode (1, 5). A tentative action spectrum for this phenomenon was published by Weintraub and McAlister (10), and this has been recently revised by Weintraub and Price (11) to include further data. Weintraub and his collaborators have used continuous irradiations of very low intensity to produce their inhibitions.

In this paper the authors wish to present an action spectrum for internode inhibition produced by very short exposures of higher intensity. The details of these experiments will be reported elsewhere. An outline of the experimental procedure is as follows. Seeds of *Avena sativa* var. "Victory" were husked, laid out on moist absorbent cotton—thirty to a dish, and grown in complete darkness in 90 per cent relative humidity and at a temperature of 25° C. After 1.5 days, when the first internodes were 2.2 mm. long, the seedlings were irradiated with monochromatic light isolated from mercury and sodium arc spectra by means of glass and liquid filters. The intensity of the exposures was measured with a calibrated electronic photometer; the time was varied between 1 and 1,800 seconds. The plants were then returned to the dark, and the lengths of the internodes measured at the age of five days. By this time the first internodes had completed their growth, the dark-grown controls having attained an average length of 67 mm. The inhibition

was calculated by dividing the average decrease in length of the irradiated internodes over that of the dark-grown controls by the average length of the internodes of the dark-grown controls. The amount of energy required to give a 10 per cent inhibition at each wave-length was determined from graphs showing the relationship between percentage inhibition and total energy of irradiation. The reciprocals of these values, corrected for their quantal content, are shown in figure 1. The values reported by Weintraub and his collaborators (10, 11) are also shown for comparison.

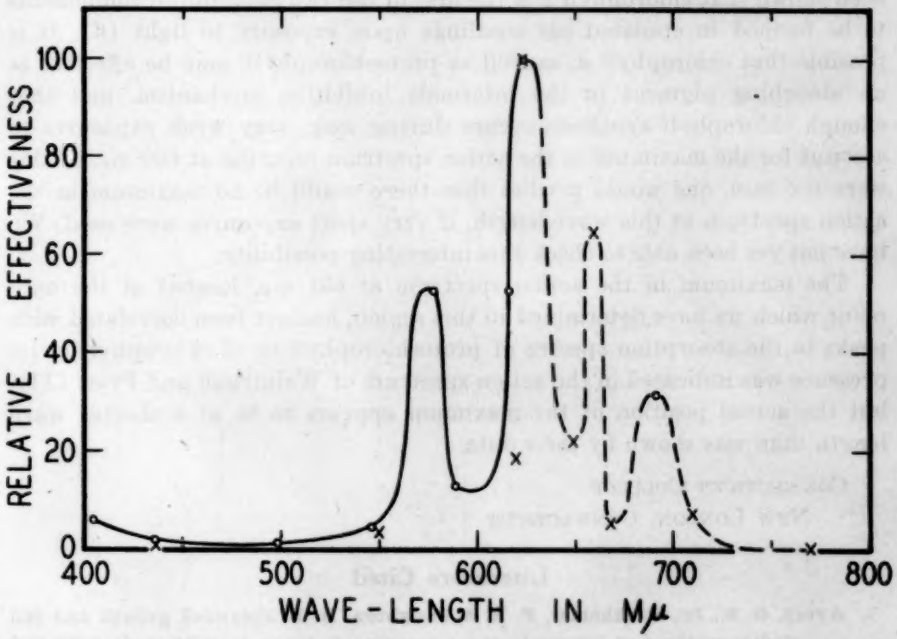


FIG. 1 An action spectrum for the inhibition of the first internode of *Avena*. Ordinates are proportional to the reciprocals of the quanta required to produce a given amount of inhibition and are expressed as percentages of the highest value. Circles represent our data for a 10% inhibition produced by short exposures. Crosses are for the data of Weintraub and Price (11), who used continuous illumination. A solid curve has been drawn through our data between 400 and 630 mμ. A broken line has been drawn between all the available points at longer wave-lengths. It is not at all certain that the action spectrum obtained by using short exposures would follow the curve in this region of the spectrum (see discussion in the text).

This action spectrum shows maxima in the red at 623 mμ and in the yellow at 577 mμ. The latter peak has not to our knowledge been previously reported. It seems highly significant that the positions of these maxima coincide with maxima between 620 and 629 mμ and between 560 and 576 mμ reported for protochlorophyll (4, 8, 9), a pigment which has been shown to

be present in etiolated oat seedlings (4, 6). There is no indication of a maximum in the blue at 436 mμ, which is very close to the protochlorophyll maximum at 440 mμ. The reason for this may well be that the large quantities of carotenoid pigments present in the seedlings (4) are acting as a color filter at this wave-length.

The maximum in the action spectrum at 660 mμ reported by Weintraub and Price (11) does not coincide with any protochlorophyll absorption band, but does fall directly on the main chlorophyll *a* absorption maximum. It has been shown that chlorophyll *a* is the first of the two chlorophyll components to be formed in etiolated oat seedlings upon exposure to light (6). It is possible that chlorophyll *a*, as well as protochlorophyll, may be effective as an absorbing pigment in the internode inhibition mechanism, and that enough chlorophyll synthesis occurs during long, very weak exposures to account for the maximum in the action spectrum reported at 660 mμ. If this were the case, one would predict that there would be no maximum in the action spectrum at this wave-length, if very short exposures were used. We have not yet been able to check this interesting possibility.

The maximum in the action spectrum at 691 mμ, located at the only point which we have determined in this region, has not been correlated with peaks in the absorption spectra of protochlorophyll or of chlorophyll *a*. Its presence was indicated in the action spectrum of Weintraub and Price (11), but the actual position of the maximum appears to be at a shorter wave length than was shown by their data.

CONNECTICUT COLLEGE
NEW LONDON, CONNECTICUT

Literature Cited

1. **Avery, G. S., Jr., Burkholder, P. R. & Creighton, H. B.** Polarized growth and cell studies in the first internode and coleoptile of *Avena* in relation to light and darkness. Bot. Gaz. **99**: 125–143. 1937.
2. ————————. Growth and cell structure in the first internode and coleoptile of *Avena* as affected by red, green, blue, and violet radiation. (Abstract.) Am. Jour. Bot. **25**: 10s. 1938.
3. **Du Buy, H. G. & Nuernbergk, E.** Weitere Untersuchungen über den Einfluss des Lichtes auf das Wachstum von Koleoptile und Mesokotyl bei *Avena sativa*. Proc. Akad. Wetenschap. Amsterdam **32**: 808–817. 1929.
4. **Frank, Sylvia R.** The effectiveness of the spectrum in chlorophyll formation. Jour. Gen. Physiol. **29**: 157–179. 1946.
5. **Goodwin, R. H.** On the inhibition of the first internode of *Avena* by light. Am. Jour. Bot. **28**: 325–332. 1941.
6. **Goodwin, R. H. & Owens, Olga v. H.** The formation of chlorophyll *a* in etiolated oat seedlings. Plant Physiol. **22**: 197–200. 1947.
7. **Johnston, E. S.** Growth of *Avena* coleoptile and first internode in different wave-length bands of the visible spectrum. Smithson. Misc. Coll. **96** (6): 1–19. 1937.

8. **Noack, K. & Kiessling, W.** Zur Entstehung des Chlorophylls, und seiner Beziehung zum Blutfarbstoff. I. Mitteilung. Zeits. Physiol. Chem. **182**: 13–49. 1929.
9. **Strain, H. H.** Leaf xanthophylls. Carnegie Inst. Wash. Publ. **490**: 1–147. 1938.
10. **Weintraub, R. L. & McAlister, E. D.** Developmental physiology of the grass seedling. I. Inhibition of the mesocotyl of *Avena sativa* by continuous exposure to light of low intensities. Smithson. Misc. Coll. **101** (17): 1–10. 1942.
11. **Weintraub, R. L. & Price, L.** Developmental physiology of the grass seedling. II. Inhibition of mesocotyl elongation in various grasses by red and by violet light. Smithson. Misc. Coll. **106** (21): 1–15. 1947.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, No. 1, pp. 22–44 JANUARY, 1948

A PHYSICAL ANALYSIS OF THE OPENING AND CLOSING MOVEMENTS OF THE LOBES OF VENUS' FLY-TRAP

OTTO STUHLMAN, JR.

Few botanical mechanisms have aroused so much interest, in the field of the "carnivorous," as the trap-like structure at the end of the spatulated petiole of *Dionaea muscipula*.

Lloyd (1), in his monograph on "The Carnivorous Plants," described the trap as consisting of two lobes, united along the middle line by a thick midrib, which has often been considered a hinge, but which has no hinge action. The lobes have their greatest thickness at the base but become thinner gradually as the margin is approached, where they thicken locally by the enlarged bases of the marginal spines. These are prominent, tapering,

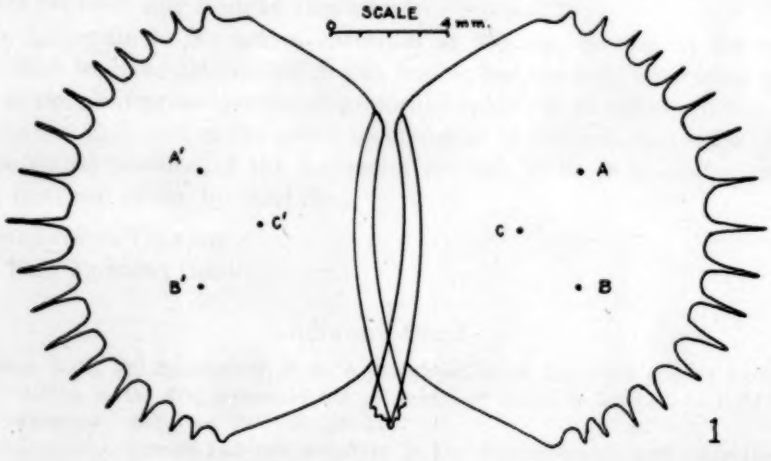


FIG. 1. Scale drawing of the inner surfaces of the lobes of *Dionaea muscipula*, showing the relative positions of the trigger-hairs with respect to the margins of the lobes.

finger-like processes which Solereder (2) opines are emergences. They are so placed that when the two concave surfaces of the lobes close, the spines approach each other and interlace like the fingers of closed hands.

On each inner surface of the concave sides of the lobes are usually found three spike-like organs. Figure 1 shows their average relative positions. They are described by Lloyd as located at the angles of a triangle placed in the middle of the lobe with its base nearer and parallel to the outer ciliated margin.

The closure of the trap, according to Lloyd, is "a seismonastic movement." This movement normally follows when the sensitive or trigger-

hairs are disturbed, as Curtis recorded as early as 1834. Lloyd (p. 188) states that Darwin described the closure of the trap as passing through two phases. "There is at first a sudden response, bringing the edges of the lobes into some approximation, enough at least to bring the cilia (marginal spines) in position so as to make a sort of cage which can prevent the escape of sufficiently large prey. This is followed by a slow movement during which the lobes are closely apposed, pressing together, their marginal regions curved outwards." These will be referred to as the shutting and narrowing phases of closure to bring the descriptions in line with Ashida's (3) studies on the leaf movements of *Aldrovanda vesiculosa*.

The closure movements, according to Batalin (4), are accompanied by a contraction of the upper or inner surface, and a comparable expansion of the lower surface of the lobes which takes place both in a longitudinal and transverse direction. Brown's (5) measurement, after allowing for changes in surface curvature, indicated however that the surfaces did not change in area by amounts greater than the experimental error.

When the lobes are separated they retain this position as if they were under tension. By applying a sufficiently large torque to the end of a trigger-hair, the resulting stimulus seems to destroy a state of internal equilibrium upsetting the balanced forces and torques so that closure rapidly follows. Reduced to its simplest form, the stimulus starts a train of events resulting in a sudden reduction of the stresses retaining the lobes in their open position.

Since closure is known to take place in a fraction of a second, the releasing activity has been attributed to a sudden loss of turgor of the inner epidermis, which need not proceed beyond an initial stage, before a mechanical collapse of the frame of the structure sets in.

The nature of the stresses and the types of motions that are exhibited during the closing and opening movements of the lobes have, however, never been analyzed in terms of fundamental physical principles.

The present analysis of the movements of the lobes was undertaken to establish the fundamental dynamical laws governing the opening and closing movements common to all sizes and ages of traps, to determine the controlling factors producing the changes in speed and configuration of the movements, the influence of the geometrical distribution of the trigger-hairs on the degree and order of the activities of the lobes, to measure the time elapsing between excitation and response, and then to hypothecate a hydrostatic mechanism that will possess all of the above established properties and relations, with the hopes that the plant physiologist can use these established dynamic activities of the plant in the furtherance of his study of the irritable mechanism causing the sudden changes in turgor of plant cells.

The Opening Movements of the Lobes. The opening of the leaf trap, after it has unrolled from the blade, is considered as due to its slow enlargement by growth. The initial opening of the trap is unquestionably a growth process; the separation of the lobes is asymmetric in that the apex of the trap opens last.

Any subsequent openings after the trap has been excited to closure should also be indicative of a growth process and be representable as a classical sigmoid growth curve whose graphical differentiation should produce a typical distribution in time curve showing the progressive changes in speed of the opening motions of the trap.

The opening movements were followed with the aid of a traveling micrometer microscope with Ramsden eyepiece. The cross hairs were focused on the external margins of the closed trap at the point of highest curvature, halfway between the apex and base of the lobes, and the chords of the arcs described by the edges of the leaf were measured. Typical mesurements were evaluated from large, green, young traps that were recovering for the first time from their initial, mechanically stimulated, closure. These traps were excited to closure by vigorously tilting either one of the lower trigger-levers C or C′ of figure 1, with the aid of a fine steel wire terminating in a small hook.

Curve CSGA, figure 2, represents a typical set of data showing the progressive increase in the linear separation of the margins of the lobes as a function of time. This appears to be a typical sigmoid growth curve. If successive increments in this linear displacement are plotted as a function of time, the broken graph B, then represents the apparent speed with which the lobes separate. This distribution could have been equally well obtained by graphically differentiating the linear displacement curve CSG.

The ascending phase of this velocity distribution curve B is slightly steeper than the descending phase. The maximum reflects the property of the point of inflection of the sigmoid curve showing that at this point, a transition takes place from an increasing to a decreasing speed in the opening movements.

Ideally the growth curve should have a symmetrical S-shaped structure, depicting a geometrically expanding phenomenon in time subjected to self-imposed limitations which, starting at the point of inflection, produce the phase of retardation. It was conjectured that the shape of the basic curve may have been influenced by the duration and distribution of sunlight on the plant which affected the speed of the opening. Hence traps were sprung at various times during the day so that the initial opening phase took place under a variable intensity of diffuse daylight in the month of May. The

evaluated observations were obtained when the room temperature of the air was 25° C.

In the typical example presented in graph CSGA, figure 2, the trap was sprung at time 1530. Two and one-half hours later the first appreciable increase of distance between the inner edges of the margins of the lobes was observable as a 0.1 mm. separation. Subsequent measurements showed the separation of the lobes to proceed at a rapid pace until they were about half open, as indicated by the maximum in the broken distribution curve. From this point onward the movements gradually decreased in speed. After 28 hours the increments of displacement per hour suddenly increased at G, indicating a departure from the phase of retardation in the opening movements.

Various traps of about equal maturity were later excited to initial closure at time 830, 1030, 1500, and 1900 so that the period of darkness was distributed throughout the various phases of the opening movements. In all cases the half-open position seldom departed by more than an hour from its associated point of inflection on the typical sigmoid growth curve shown in figure 2. The ideal limitations set on the acceptability of the results were such that the traps of necessity must be excited to closure by stimulating identically located trigger-hairs with identical applied torques, despite the different physiological conditions of individual leaves, which at a given time and place may not produce identical but will give dynamically similar responses.

While many variations from the ideal conditions were rejected, the results on the whole showed that no basic variations, in the form of the growth curve, were observed except those attributable to changes in the degree of excitation and the variation in the trigger-hair-pattern used to stimulate the trap to closure.

Since the distribution curve (B) showed a rapid change in speed during the middle period of its opening phase, and since a decrease in speed is attributable to the introduction of a frictional force factor it was suspected that the interlocking marginal spines were the cause of the phase of retardation.

It was found, however, that the marginal spines were always disengaged before the opening exceeded the half-open position (S). Subsequent changes in the slope of the growth curve cannot therefore be attributed to any frictional retarding force contributed by the marginal spines. One of the sources of error, in evaluating a typical situation, was however found to be due to one or more crooked overlapping spines. This entanglement did introduce a hang-back-force which modified the basic opening motion until the spines were disengaged.

To prove that the presence of the marginal spines did not contribute modifications in the basic opening motion, comparable traps were examined for changes in opening speeds before and after the spines had been clipped

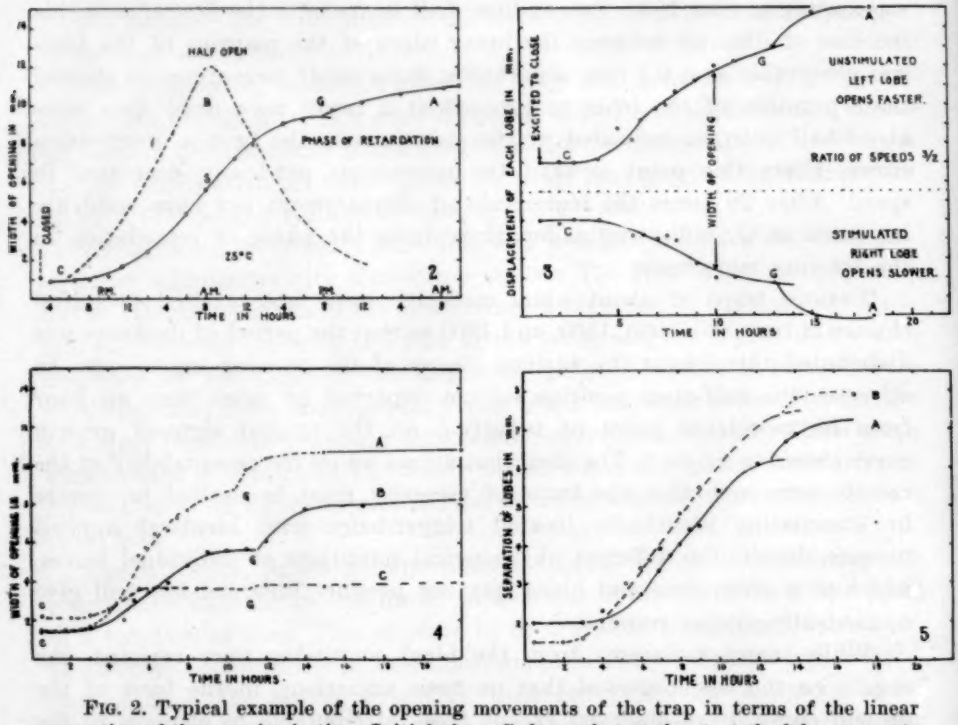


FIG. 2. Typical example of the opening movements of the trap in terms of the linear separation of the margins in time. Initial phase C shows that at the start the lobes separate slowly but progressively move faster until about half open. At this point the phase of retardation sets in, and is completed at G. Phase GA is interpreted as the reversion to the basic growth curve after complete recovery from excitation has taken place. Broken curve shows rate of separation of lobes with time. Maximum speed is attained at B, reflecting the point of inflection S of the displacement curve. FIG. 3. The movements of individual lobes show that the spreading phase of the recovering lobes CG differs from growth movements GA. CGA is interpreted as a composite motion due to two processes. Recovery is completed at G where the built-up hydrostatic pressure restored the lobes to their near preclosure position. This is followed by the phase GA which represents the rate of separation due to normal growth. FIG. 4. Recoveries from successive stimulations producing closure. The first recovery is A, the second is represented by B, while C is the fourth recovery. Relative changes in slope indicate degree of progressive inability of the lobes to recover from the previous excitatory process. FIG. 5. Curve A shows the rate of separation of the lobes after a vigorous stimulation. B, the opening of the same trap after stimulation due to a single lower trigger-hair C. Results show recovery of B to be faster than A, despite data B antidating A.

close to the margins of the lobes. This technique was permissible because Munk (6), as early as 1876, had noticed that stimulation was not procurable by cutting the outer marginal zone of the cilia.

It was found that the absence of the marginal spines did not change the form of the basic recovery curve.

In order to explore the persistence of what at first sight appears as an error in the observations at G in figures 2, 3, and 4, and where the data depart from the smooth basic curve, the movement of the individual lobes, in the process of opening, was measured.

The departure from the basic opening curve is shown in detail in figures 3 and 4, at G. Apparently, the phase GA identifies a real departure from the basic recovery phenomena depicted by the graph CSG in figure 2. It is attributed to the dominance of the normal growth process, in the life history of the leaf, after the lobes have recovered from the excitatory process, and have re-established their normal rate of growth.

Figure 3 shows the linear displacement of the left and right lobes of a large young trap that possessed no irregular interlocking marginal spines. This trap was sprung at time 1300 in diffused (May) daylight at 25° C. The observations extended over a period of 18 hours. Two hours after closure the lobes began to separate.

It can be seen that a measurable recovery from closure did not set in as an observable movement until several hours after closure. The faster moving left lobe had a recovery period of two hours, while the stimulated right lobe developed a measurable movement after a recovery period of four hours.

The relative slopes at the half open stage of the two recovery curves indicate that the left lobe was moving about 50 per cent faster than the right lobe. Despite the asymmetry of the movements, the maximum open position has within the limits of interpolation, been attained in about the same time in both lobes.

In order to produce more symmetric opening movements of the lobes, it was found necessary to stimulate both lobes in identical ways. This can be accomplished by applying equal torques simultaneously to the two symmetrically placed trigger-hairs C and C′. A difficult, and more often than not, an unsuccesssful technique.

A close approach to symmetric opening movements were obtained, after closure movements were induced, by sweeping over all six trigger-hairs in one motion with sufficient force to produce symmetrical closure.

If C on the right lobe was used as a source of the stimulus, the right lobe moved faster than the left lobe on closure. On recovery (opening) the right lobe moved more slowly. In general, the lobe to which the mechanical stimulus was applied opened more slowly than the opposite unstimulated lobe. This raises the question of the exact functional relation between the speed of recovery and intensity of the excitatory process, producing closure at a given temperature.

Recovery from Repeated Closure Movements. The lobes of a trap, after their first collapse due to a just sufficient stimulus to produce closure, will reopen (at 25° C) as illustrated in figure 4, graph A. The rapidity of the recovery is indicated by the general slope of the sigmoid curve. The recovery from the stimulus is presumably completed at G. Apparently the slower normal growth phenomenon was screened by the more rapid recovery movements, so that the remainder of the graph GA can now be attributed to a reversion to the normal speed of the leaf growth.

Twenty-eight hours later the same trap was sprung once more, by mechanically exciting the same trigger-hair in the same way. Its opening movements are depicted by graph B. The general slope of this graph is less than the slope of A. It is therefore moving much more slowly during its second opening than during its first opening movements.

Graph C in figure 4 shows the opening movements of the trap after it had been stimulated to closure the fourth time. Its recovery is now very slow in its initial phase of opening. It will be noted that the successive positions of maximum separation of the lobes are progressively smaller, despite the fact that the trap had recovered completely from its excitatory state, and had presumably re-established its normal rate of growth as is shown at G by the sudden change in slope in the upper phase of each growth curve. The lobes also take longer to recover from the excitatory process after successive closures.

This lack of complete recovery from the repeated daily excitations to closure, as indicated by the decreasing ability of the lobes to attain their original greatest separation, must be due to a change in the elastic modules of the structure or to the inability of certain layers of cells to develop the necessary hydrostatic pressures to displace the lobes to their initial maximum positions. This indicates that as a result of the excitations a more rapid than normal rate of ageing was produced.

How the speed of recovery varies with the intensity of the stimulus supplied by the trigger-hairs is illustrated in figure 5.

Graph A shows the opening motion, after two previous closures, of a trap which had been stimulated by vigorously exciting all six of the trigger-hairs. Graph B shows the opening of the same trap after it had been excited to closure by a critical excitation of a single lower trigger-hair. Note that the recovery of B is more pronounced and much faster, despite its previous three closures. This is indicated by the fact that graph B lies above graph A and that it possesses a larger slope than A. This seemingly contradicts the evidence submitted in figure 4. This inversion of speed of opening is, however, due to the change in intensity of stimulation. Had the trap been as vigorously stimulated to closure in its B as in its A excursion, B would

have fallen below A with a slope less than A. Because the speed of recovery is, however, approximately inversely proportional to the intensity of the stimulus producing closure, it follows that the response to the smaller intensity of the closure stimulus resulted in a faster recovery motion which more than compensated for the normal decreasing sensitivity of the plant.

As more precise data become available, as a result of a more quantitatively reproducible excitation technique, it should be possible to arrive at a more exact relation between intensity of the mechanical stimulus and the speed of recovery. At present, the results are sufficiently reproducible so that the following qualitative deductions can be made.

The greater the intensity of the stimulus, the slower the recovery. If the stimulus is applied to a single lobe to produce closure, then the unexcited lobe moves faster on opening than the excited lobe. Symmetry of opening can only be attained if both lobes are excited at the same time, identical stimulating patterns and intensities being used. Recovery from successive excitations is progressively slower.

Speed of Closure. Lloyd (p. 191) showed in his reproduction of six successive frames of a motion picture study of the vertical aspect of the trap, that closure can take place in less than a half second.

It will be shown that the time to complete the closure of previously unexcited traps, maintained at 25° C, can be controlled by the number and distribution pattern of the trigger-hairs used to initiate the excitatory process leading to closure.

In order to analyze the rapid closure movements in detail, a motion picture camera was used. It had a speed of 16 frames per second, and an exposure time of 1/90 second per frame.

The closing motion of the trap was photographed from two positions. The *vertical aspect* allowed one to follow the decrease in the distance between the margins of the lobes. This reduction in the width of the trap will be referred to as the *linear closure*. In the *horizontal aspect*, the camera was focused on the apex of the midrib, so that the V-shaped distal edges of the lobes were photographed during the closure motion. This horizontal aspect allowed one to analyze the angular motion of the end of the trap. The latter will be referred to as the *angular closure*.

Figure 6 is an analysis of a typical example of a nearly symmetric, high speed angular closure, as recorded at 1/16 second intervals.

The angular separation of the lobes of the trap, where they converge into the midrib, was measured from the (20 ×) enlarged photographic negatives, to the nearest angular degree.

The initial angular separation of the lobes was usually about 45°. The trap was considered closed when four successive frames (4/16 sec.) showed

no variation greater than one degree. This particular closure showed the characteristic response to a mechanical stimulus, described by Lloyd as a "seismonastic movement." It completed its 31° closure in 7/16 second.

The graph shows that the trap begins to close gradually, and gains

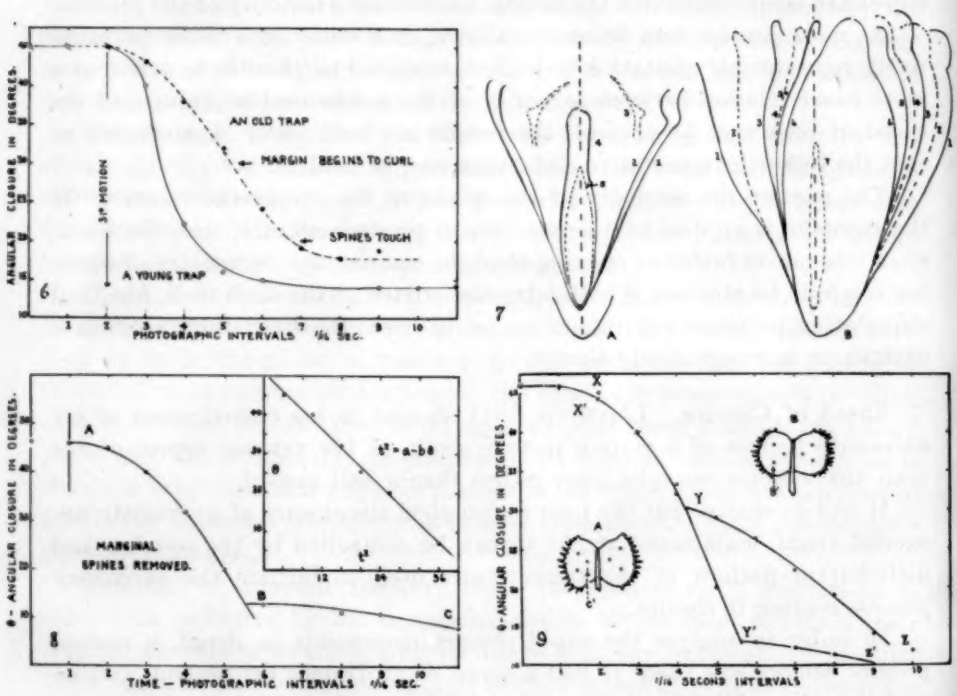


FIG. 6. Angular closure in degrees depicted at $\frac{1}{16}$-second intervals. Basic motion obscured by the presence of interlocking spines. FIG. 7. A. The angular aspect of symmetrical movements of the closing lobes were traced from enlarged photographs spaced $\frac{1}{16}$ seconds apart. Marginal contact is made in position 4. Constriction takes place from 4 to 5 during six $\frac{1}{16}$-second intervals. B. An asymmetrical excited and asymmetrical closure action of a trap in its vertical aspect. Contact of the margins is attained in interval number 6. Delayed action, due to constriction, progressively increased from position 6 to 7. FIG. 8. Basic closure movement develops when marginal spines are removed. Parabolic curve AB regraphed in terms of angular displacement θ and t^2 shows that the decrease in angular separation is directly proportional to the square of the time until contact of the margins takes place at B. BC shows how the free movement AB is decelerated by a retarding factor, contributed by the increasing area of contact of the lobes as they constrict. FIG. 9. Basic motion of the same trap excited to closure in two different ways. XYZ represents motion due to excitation by trigger-hair B′, X′Y′Z′ due to C′. Identical basic motions are produced until ciliated edges touch at Y and Y′. The squeezing action YZ proceeds faster than Y′Z′ due to the asymmetrical approach of the edges of B.

angular velocity as the motion proceeds until the angular opening is reduced about one half, after which it loses speed as a result of a superimposed secondary retarding action. In its initial descent the graph depicts the lobes as decreasing their angular separation as if they were elastically hinged

trap doors. In this first phase of the motion the spinal margins move with a greater angular speed than the lower edges of the lobes, until they make contact. At this point the second phase or squeezing process sets in, shown by the flattening of the central oval aperture. This squeezing action starts at the upper margins, moves down the faces of the lobes until only a narrow oval slit remains. The speed of this squeezing action depends on the degree of excitation.

Figure 7a depicts the composite tracings from the motion picture negatives of the successive positions of the distal edges of the lobes. From this tracing it can be seen that a nearly symmetrical angular closure was produced by critically exciting trigger C on the right lobe. The start of the angular excursion is not so sudden as one is led to expect from visual observation.

In general, the greater the asymmetric position of the stimulus initiating the excitatory process, the less symmetric the final shape of the slit when the closure ceases.

In order to show that the lobes do not leave their rest position with a trigger-like start, but move from this position by building up their velocity in a normal way, the slower closure movements of an older trap is presented in the broken graph in figure 6. In the later phase of the motion the spines introduce a modification in the basic closure motion in the form of an external retarding force. If this external retarding force is removed by clipping these spines, a more basic motion results, simulating the angular closing of a trap door under the action of a constant applied force.

Figure 8 illustrates how a trap, with its marginal spines clipped to eliminate external frictional factors, moves during its third successive closure. The trigger C′ on its left lobe was used as a stimulating center to initiate the excitatory process. It will be noticed that the angular closure movement is unquestionably made up of two fundamental actions, AB and BC. The form of the trace AB shows that the speed is built up gradually at the start. This is indicated by the gradual change in the slope of the curve at A, after which the slope changes rapidly. The whole curve depicts an accelerated motion which suddenly terminated at B when the distal and ventral edges of the lobes came into contact. This phase of the motion was completed in this particular trap, in 9/32 sec.

A parabola of the form $t^2 = a - b\,\theta$ has been plotted through the points of observation. The degree of precision with which the data match the above relation is shown in the insert of figure 8. The curve does not depart from the data by more than four per cent.

The first phase of the closure is a typical dynamical action exhibiting a decrease in angular displacement proportional to the square of the time, i.e.

$-\theta$ *proportional to* t^2. The minus sign indicates that the angular opening is decreasing as the time increases. From this it follows that the increase in angular speed is directly proportional to the time elapsed since the start of the motion, and that the angular acceleration is constant during the motion. This acceleration is attributable to the actions of the restoring forces, inherent in the structural units of the lobes, which come into play when a hydrostatic pressure maintaining the lobes in their distended positions, is suddenly removed.

The first phase AB of the closure is reducible to the classical motion of a rigid body rotating about a vertical axis, under the action of constant normally directed forces. Applying D'Alembert's principle, which asserts that the whole effective forces of a system when reversed are together equivalent to the impressed forces, and taking moments (T) about the midrib as an axis of rotation, we obtain

$$T = \Sigma mr^2 \frac{d^2\theta}{dt^2}$$

where m is the mass of any element of the rotating body, r its distance from the axis and θ the angle which a plane through the axis and the elements makes with the plane of reference.

Hence

$$\frac{d^2\theta}{dt^2} = \frac{\text{moment of forces about axis}}{\text{moment of inertia about axis}}.$$

By integrating we can determine the angle through which such a body has revolved in a given time.

Hence, if F is the resultant of the applied constant normal forces, developed by the frame of the lobe to restore it to its closure position, acting at some point located at a distance r from the axis of rotation, and M is the mass of the lobe, of radius of gyration k, then

$$\frac{d^2\theta}{dt^2} = \frac{-Fr}{Mk^2}.$$

The solution

$$-\theta = \frac{Frt^2}{2Mk^2}$$

shows that the decreasing angular displacement θ is proportional to the square of the time, and is proportional to the applied torque Fr impressed upon the lobe by the stress inherent in the strained frame as a result of its open position.

The second phase of the closure (BC in figure 8) was completed in about 9/16 second, as a squeezing action of the lobes. This is also a parabolic graph, flattened to such an extent that it appears to be linear. It is therefore a continuation of the same phenomena. It represented a slowly decelerating motion with a retardation factor introduced by the continuously increasing

area of contact of the opposing surfaces, which bring the lobes gradually to rest.

That the above motions cannot be simulated by the bending action of a bimetallic strip of metals of different coefficients of expansion with change in temperature, as was proposed by Lloyd (p. 192), is evident when we consider that the latter motion develops a logarithmic deflection in equal increments of time, when the emission or absorption of radiant energy takes place at a constant rate.

This analysis shows why the outer margins of the trap appear to move with such a sudden snap as compared with the creeping motion or squeeze at the middle of the lobe, which completes the closure. The average ratio of these angular speeds is about 8 to 1.

Speed of Closure Depends on Pattern of Excitation. If the inner surface of a lobe composed of certain specialized cells is the seat of the irritable tissue, and if their state of irritability can be assumed to be due to their degree of polarization, then this surface of specialized tissue can, in a steady state, form an interrelated equipotential surface. Its equilibrium must always be attained when the lobes are distended to their maximum position. A localized destruction of the degree of polarization of a single cell in such an equipotential surface must result in a progressive spread of depolarization which could manifest itself as a spreading equipotential electrical wavefront propagated over the surface of the lobe.

Bose (7) identified and measured the speed of such an electrical wavefront in the petiole of mimosa. He found that the velocity of its propagation was of the order of 3.0 cm. per sec.

A sufficient torque applied to one of the trigger-hairs, a form of mechanical stimulus, can destroy the degree of polarization of one or more of the inner sensitive cells at the base of the trigger-hair. This is a localized change in the equipotential field. This must initiate the excitatory process, which in the form of an equipotential wavefront could spread across the inner face of the lobe.

The pattern of the wavefront should be controllable by using different combinations of trigger-hairs as sinks of energy from which a negative equipotential depolarizing wavefront can originate. Such a controlled wavefront should therefore determine the closure movements of the lobes.

Figures 7A and 7B are introduced in order to indicate that the form of the closing motion changes with the position of the trigger-hair used to start the excitatory process. These figures are composite tracings of the successive positions of the distal edges of the lobes, as photographed at 1/16 sec. intervals. In figure 7A the stimulation of the trigger-hair C′ produced nearly symmetric movements of the lobes. In 7B, the left lobe was stimulated

by means of the trigger-hair B′ located near the basal edge facing away from the observer. Note how much faster the left side was moving in the initial phase of the closure than the right side. The squeeze begins as soon as the upper margins make contact and the area of contact increases until a small slot is left between the lobes just above the midrib. On comparing these two slot-like residual separations we note that in the symmetrically excited lobes this opening is symmetrically placed with respect to the midrib. In the asymmetrically excited lobes the residual opening is flatter on the left side, showing how the initial closure movement follows through and continues with its greater speed into the final squeezing motion, leaving the distorted slot as a residual separation. When the motion ceased, equilibrium must have been attained between the stress developed by the closing frame, and the recovering hydrostatic pressures.

In figures 9 is shown an analysis of motions analogous to those depicted in figures 7A and 7B.

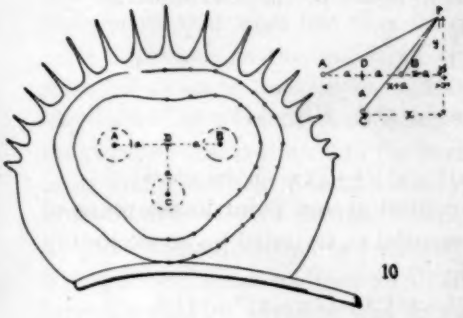
Note that the two graphs represent identical motions up to the points Y and Y′ where the marginal edges make contact, after which they go over into their second closure phase where the angular displacements proceed more slowly. These two closure patterns were obtained from two traps that were about the same age, shape, and size and possessed the same initial angular opening.

Since in X′ Y′ Z′ the excitatory process must spread from the symmetrically located trigger C′ to the margins of the left lobe, and also from C′ across the midrib to the right lobe and thus to its margins, it of necessity follows that the movements of the left lobe should precede those of the right lobe. The movements of the margins are nearly symmetric, so that the initial contact is made by the external edges of the upper margins at about the same time. This contact is represented by the point Y′ which reflects a closure of about 33 angular degrees.

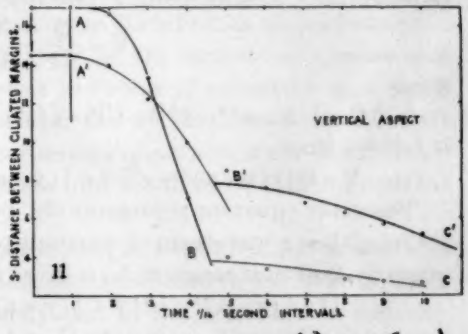
In XYZ the excitatory process spreads from the trigger-hair B′ located near the lower external edge of the left lobe. To reach the right lobe, the excitatory wavefront must also cross the midrib, but since it originates nearer the base of the lobe it follows that these lower edges respond first, hence the distal edges lag. Thus, through an asymmetric spreading of the excitatory wavefront the basal margins of the lobes make contact on closure sooner than if the lobes were symmetrically excited, hence the point Y lies higher on the graph and further to the left on the time axis.

Graph YZ shows that the second phase or the squeeze motion closes the trap 10° in about $\frac{3}{16}$ second while in Y′Z′ the trap moves 10° in $\frac{12}{16}$ second, or a ratio of angular speeds of 4 to 1 in favor of the asymmetrically excited trap. This is due to the fact that the retarding force of the contiguous basal edges is not offering so great a resistance to the motion.

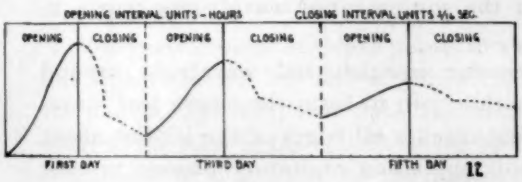
In figure 10 is shown the progressive shape of an ideal equipotential wavefront as if it were moving with constant speed over the inner surface of a lobe. The trigger-hairs A, B, C are placed symmetrically at the corners of



10



11



12

13

FIG. 10. Scale drawing of the inner face of a lobe with its three trigger-hairs A, B, and C, symmetrically spaced as indicated. If all three trigger-hairs are excited simultaneously and with identical torques it is assumed that three similar equipotential depolarizing wavefronts arise, identified by the broken circles. These combine to form the equipotential wavefronts after a short interval of time. Its expanded position, after a slightly longer interval of time, is shown as it travels over the lobe, to eventually reach all margins at about the same time. It is found that such a generalized equipotential wavefront can, on theoretical grounds, be the necessary and sufficient reason to account for excitation to produce symmetrical closure. FIG. 11. Measurements of the vertical aspect of closure. The linear distances between the ciliated margins are presented at $\frac{1}{16}$-second intervals. This shows that the linear closure varies with the square of the time, thus proving that this aspect of the basic motion is identical with that shown in figure 7. FIG. 12. Semidiagrammatic history of the opening and closing amplitudes of a single trap excited to closure every twenty-four hours. The openings are expressed in terms of 3-hour units and the closures in $\frac{1}{16}$-second intervals of time. The samples are separated by an interval of 1, 3, and 5 days. At the end of the seventh day the amplitude is inappreciably small and the trap has ceased to respond. FIG. 13. Scale drawing of a precision Bourdon pressure guage. Thin hollow bronze tube T of elliptical cross-section. Closed end attached to a multiplying device which rotates the arrow across a scale of pressure units. An increase in hydrostatic pressure applied at P deflects the closed end upward, a decrease in pressure moves this end down bringing the two ends closer together. The cross-section of *Dionaea* shows the lobes distended under hydrostatic pressure, presumably developed by the layer of cells in the inner epidermis. Broken outline of lobes shows position under decreased hydrostatic pressure. Inner constriction shows upper margins in contact under minimum hydrostatic pressure.

the triangle ABC so that the distances AD = DB = DC = a. If the three trigger-hairs are bent so that they produce equal disturbances of magnitude Q which locally rupture the equipotential surface, then the resultant drop in potential V at some point P (see insert in figure 10) is determined by

$$V = \frac{Q}{AP} + \frac{Q}{CP} + \frac{Q}{BP}$$

Since

$$AP = [(x+a)^2 + y^2]^{\frac{1}{2}};\ CP = [(y+a)^2 + x^2]^{\frac{1}{2}};\ BP = [(x-a)^2 + y^2]^{\frac{1}{2}}$$

it follows that

$$V = Q\{[(x+a)^2 + y^2]^{-\frac{1}{2}} + [(y+a)^2 + x^2]^{-\frac{1}{2}} + [(x-a)^2 + y^2]^{-\frac{1}{2}}\}$$

Since the equation represents the potential at any point in the plane of the lobe, then a wavefront of constant potential C, initiated by an excitatory quantity Q of unit magnitude, is given by

$$C = [(x+a)^2 + y^2]^{-\frac{1}{2}} + [(y+a)^2 + x^2]^{-\frac{1}{2}} + [(x-a)^2 + y^2]^{-\frac{1}{2}}$$

Assigning specific values to C and solving for the coordinates x and y for a value of a = 2, we obtained the equipotential wavefronts shown in figure 10.

Note that as the original circular equipotential wavefront around each trigger-hair A, B, C spreads, they join to form the clover leaf wavefront, which upon further spreading reaches all edges of the lobe at about the same time. Such a symmetrically spreading excitatory process in each lobe can produce a symmetrical closure response. On the other hand, a point excitation originating at a single trigger-hair develops a circular spreading excitatory wavefront which cannot reach all edges at the same time. This produces an asymmetrical closure of the lobes.

We may therefore conclude from both the experimental and theoretical evidence that the shape of the wavefront of the excitatory process determines the pattern of closure.

Does the Midrib Participate in the Closure Movements? Batalin agreed with Darwin (8) that there was a slight contraction of the upper and an accompanying expansion of the lower faces of the lobes, in both a longitudinal and transverse direction. If these were appreciable changes, one would expect that midrib to show a change in curvature as a result of the strains developed in the attached surfaces.

Since the wavefront of the excitatory process in an asymmetrical closure movement must cross the midrib at an angle, one would expect to detect a twist in the midrib if it participated in the closure movement. If the closing motion of the lobes is symmetrical, then no twist should take place when the excitatory wavefront crosses the midrib. If any appreciable reduction in hydrostatic pressure takes place in the midrib during the passage of the excitatory wavefront across this structure, then a change in curvature of the midrib must take place.

In order to test this hypothesis, two independent methods of observation were resorted to. In the first method, a micrometer microscope was focused on a point on the apex of the midrib. The trap was sprung and the displacement of end of the midrib was measured to the nearest tenth of a millimeter. Movements that were less than 0.1 mm. were classified as *no motion*.

An increase in the radius of curvature of the midrib on closure was recorded as an up movement, a decrease in radius of curvature as a down movement. As a result of twisting motion the up movements should shift the point of observation into the first or second quadrant or the down movement would shift the point of observation into the third or fourth quadrant of the field of view of the microscope.

The evidence conclusively showed no motion in 4 closures, and measurable but not consistent motions in 31 closures. Inconclusive evidence from a large number of closures was primarily due to the unavoidable displacement of the microscope image when too much force was used to bend a trigger-hair.

The predominant evidence points to a motion producing an upward twist due to asymmetric excitation, indicating a slight decrease in curvature of the midrib. The composite data indicated that on the average the displacement of the apex of the midrib moved in most cases from 0.2 to 0.4 mm. This conclusion is supported by the photographic records obtained from the angular closure movements which often showed a slight rise in the apex after closure.

In order to get more direct evidence of a change in curvature of the midrib due to closure, it was found necessary to photograph the trap in profile. This evidence was not very conclusive. In the majority of cases the apex of the midrib was slightly raised on closure but the resulting straightening of the rib was not sufficient to warrant a quantitative estimate of the change in curvature. From the observed motions one can only conclude that the midrib reacts to, but does not cause the closure movements.

The Vertical Aspect of Closure. The motion picture records of the vertical aspect of the closure movements were obtained in order to investigate the rate at which the distance between the margins of the lobes decreased. Since the margins swing on an arc of a circle, the photographic record in this aspect of closing only reveals the motion of the chord of the circular motion.

In the tenfold-magnified projected photographic images, the measurements across the width of the open trap were in error of not more than 2mm. in 120 mm., or not more than 2 per cent. The arc described by the margins is about 4 per cent longer than the linear displacements shown in the photographic enlargements. This latter error becomes negligibly small

when one considers the variation in terms of the overall dimensions of the lobes which range from 0.8 to 1.4 cm. in depth.

The basic pattern of the closure curve is shown in figure 11. The lobes approach each other with a rush until the distal and proximal ends of the marginal lips collide, leaving an oval opening covered by the overlapping spines, shown in figure 7. This oval aperture then begins to constrict until contact is made along the whole upper marginal edge. The basic graph therefore depicts two motions, AB the displacement of the margins, the short transition phase at B which degenerates into the squeezing action BC, during which the margins of the oval aperture constrict. These motions are the counterparts of similar actions depicted by the horizontal aspect of the angular closure.

The sudden almost symmetric starting actions and subsequent rapid accelerations are characteristic of the initial closing of all young vigorous, green traps mechanically excited by bending one of the two lower trigger-hairs C or C′ of figure 1.

If the marginal trigger-hairs A, A′ or B, B′ are used to excite closure, the margins approach each other at an angle. If A or A′ is plucked the distal edges of the margins lead. If B or B′ is plucked the proximal edges of the margins lead. If the spines are clipped off at the margins of the lobe, no changes in the basic patterns of closure were observable.

If a trap was cut from its petiole or if the petiole was crushed, no change in the basic closure pattern was produced.

Basic Closure Curve of the Vertical Aspect. In order to resolve the composite motion of the vertical aspect of the basic closure graph, it was necessary to obtain data from a more slowly moving trap. Figure 11 shows how the freely moving margins accelerated from A to B, and came to a sudden stop at B when the outer edges of the margins touched. They then continued to close the oval space left between the marginal lips, with decreasing speed.

The initial phase, the free movement, is represented by the parabolic graph AB. The curve is typical of the motion of a body whose linear displacement is directed proportional to the square of the time. This confirms the results obtained from the analysis of the motion for the angular aspect of closure where the angular displacement was found to be directly proportional to the square of the time. The second phase is also identical to that exhibited by the angular closure.

Lag in Motion. An appreciable time elapsed between the initiation of the stimulus, furnished by a mechanical torque applied to a trigger-hair and the beginning of the motion of the outer margin of the lobe. This lag

in response should be equal to the time taken for the excitatory wavefront to travel from its point of origin, at the base of the trigger-hair, to the margins of the lobes.

If, in a previously unexcited trap, one of the lobes was stimulated to closure by plucking trigger-hairs C or C′, the time that elapsed between the application of the stimulus and the beginning of marginal motion, at 25°C, was as small as 3/16 second, although one trap showed a lag as large as 7/16 second. A comparable lag of from 1/4 to 1/3 of a second was reported by Burdon-Sanderson (9) for the electrical action-current flowing from the proximal to the distal end of the leaf.

In the sensitive plant *Mimosa pudica*, comparable situations have been observed. Detectable "turgor movements" have been reported to occur within 1/13 sec. after stimulation. Thus Bose (7) determined the limiting constant lag to be about 1/10 second, at maximum intensity of stimulus.

Speed of the Wavefront of the Excitatory Process. In the collection of specimens with which this work was done the average distance from an inner trigger-hair C or C′ to the nearest edge of the ciliated margin varied from 0.50 cm. in a small lobe with 1.10 cm. in a large lobe. If in a specific lobe 0.90 cm. was the distance traveled by the excitatory process in 3/16 second from its stimulating point to the ciliated margin, the excitatory wavefront must have traveled with a speed of 4.8 cm. per sec. If the same speed was maintained in crossing the midrib to reach the opposite margin, one should observe the opposite lobe to lag behind the one carrying the seat of the stimulus by from about 3/16 to 4/16 second. This lag was easily recognized in the motion pictures, since the film moved sufficiently fast so that the lag in the response was often recorded on two or more frames.

That an excitatory process having a speed of about 5 cm. per sec. is not excessive can be judged by comparing it to the speed of propagation of the excitation found by Bose (7) for *Mimosa*. At summer temperatures he found that the velocity of transmission of the excitation in the petiole was 3 cm. per sec.

Ageing as Indicated by Speed of Successive Closures. That stimulation of the leaf resulted in a greatly accelerated rate of growth accompanied by a disposition of starch in the cells of the dorsal region soon after closure occurs was reported by Brown (5). Lloyd (1) concluded from his observations that repeated daily responses were followed by decreasing sensitivity, probably due to the completion of growth.

Figure 11 is reintroduced to evaluate the successive increases in closure time as the trap ages. The graphs show two successive closures of the same trap, separated by a rest period of four days. Graph ABC depicts the first

closure as a highly accelerated motion AB in which the lobes were practically brought to rest as a result of the collision between the distal and proximal edges of the ciliated margins. The force was sufficient to bend the margin so that only a small, flattened, oval aperture remained. This oval aperture closed rather slowly, as is apparent from the small slope of the second phase or squeezing action BC. The flexibility of the structure is therefore quite large while the leaf is still young.

The second closure, as analyzed by the graph A′ B′ C′ occurred four days later. Note that the lobes starting at A′ are closer together than they were at A. They move with a slower speed as indicated by the smaller slope of the graph A′ B′. The overall time to complete the first closure of the trap was 13/16 second, while the second closure was completed in 15/16 second. On contact of the distal and proximal edges, the oval aperture was much larger, hence they collided with less momentum.

The velocity of withdrawal of the active force per unit area which maintains the lobes in their distended positions is therefore slower. This active force per unit area must take the form of an internal hydrostatic pressure.

The withdrawal of the fluid in the epidermal cells which lowers the hydrostatic pressure must therefore have taken place much more slowly in A′ B′ C′, since the resulting movements were slower. Ageing therefore affects the speed with which the specialized cells in the inner epidermis can lose their fluids, in order to lower the effective hydrostatic pressure sufficiently to produce mechanical closure.

In order to illustrate the generalized successive motions of the trap of *Dionaea*, in the form of an expected degenerating cycle, attributable to ageing, I present figure 12 as a semidiagrammatic summary of the successive opening and closing phenomena in time.

The composite motions of the expanding lobes are shown in terms of hourly units, and the successive closures in 1/16 sec. units of time. The cyclic process shows the initially rapid opening and closing motions following each other in successive longer periods of time and with successive smaller amplitudes proportional to the recovered separations of the lobes, until the reactions to the applied stimulus cease. Since not more than four successive events were ever successfully analyzed for any given trap, no quantitative evaluation of the decrement was obtained.

Opening Movements and Closure Attributable to Hydrostatic Pressure Changes. In seeking for a stress that must be removed to produce closure in response to stimulation, we join with the earlier investigators in attributing the collapse of the lobes to a rapid reduction in the turgor of specific cells.

Ashida (3) concluded from his work on the leaf movements of *Aldrovanda vesiculosa* that the motions in this form of trap were attributable to the changes in turgor of the inner epidermis. This same conclusion was independently arrived at, for *Dionaea,* by Burdon-Sanderson. Since there is a definite analogy between the structure and movements of the traps of *Aldrovanda* and *Dionaea,* one may be permitted to start from the premise that the movements of the lobes in both forms of trap are due to changes in turgor of the inner epidermis, and that the central layers of parenchyma cells with their sustaining framework reflect the elastic properties of the mechanism.

It is proposed to offer some additional support to the theory that changes in the hydrostatic pressures developed by the inner epidermis are the necessary and sufficient conditions to produce the recorded motions in *Dionaea.*

The present data exclude the possibility that the movements of recovery are primarily due to the growth of the inner epidermis.

In order to account for the mechanical opening movements on fundamental hydrostatic principles, it is necessary that the cells of the inner epidermis be longer in the direction perpendicular to the midrib than those in the outer epidermis. Since an increase in their hydrostatic pressure expands these cells in all directions, they must in addition tend to straighten themselves in the direction perpendicular to the midrib in order to account for the mechanical separation of the lobes. They should therefore mechanically conform to the same fundamental principles incorporated in the design of the sensitive pressure element in the Bourdon pressure gauge, where an increase in hydrostatic pressure straightens its functional pressure element.

The similarity in hydrostatic response and mechanical structure is strikingly apparent when we compare the sensitive tube-mechanism actuating the Bourdon gauge with the structual elements of a cross section of a lobe taken perpendicular to the midrib, as illustrated by figure 13.

The Bourdon Pressure Gauge. It is an established fact that thin-walled curved tubes possessing elliptical cross sections are very sensitive to bending flexure. The angular deflection of such a curved hollow tube, in the process of straightening, is both on theoretical grounds (Lorenz, 10), and from experience, directly proportional to the increase in the applied internal hydrostatic pressure. The Bourdon gauge (figure 13) is a mechanical device which uses this principle for measuring hydrostatic pressures. It is essentially nothing but an elliptically flattened metal tube, curled into an arc of a circle with the longer axis of its elliptical section perpendicular to the general plane of the tube. This tube is closed at its upper end. As a gradually

increasing hydrostatic pressure is applied at its lower open end, the curved tube straightens. The straightening or decrease in curvature is accompanied by a decrease in the ellipticity of its cross section. As the pressure rises the elliptical cross section gradually approaches, in the limit, a circular form because a circular form contains the largest area for a given perimeter.

In this process of straightening of the curved tube subjected to a gradual increase in internal hydrostatic pressure, the tensile forces of the fibers in the convex side and the compressive forces of the fibers in the concave side have internally directed resultant forces that can gradually be neutralized by increasing hydrostatic forces directed normal to the inner surfaces of the tube. The minor axis of the elliptic section therefore increases until the cross section approaches a circular form, at which point the straightening process of the tube ceases.

A decrease in sensitivity is obtained by either increasing the thickness of the tube or increasing its modulus of elasticity.

To make the gauge structure more sensitive to small changes in internal hydrostatic pressures, Lord Rayleigh suggested that one must replace the two uniform halves of the elliptical tube, which lie on either side of its major axis, by two symmetric curved sections which meet on the major axis at a finite angle.

Figure 13 shows a cross section of the lobes of *Dionaea*. The elongated large-celled middle layer (Lloyd, *plate 18, fig. 18*) of each half of the U-shaped structure can be considered as forming a narrow hollow element fulfilling the mechanical requirements of a very sensitive Bourdon gauge. Two of these elements are considered as joined at the base to form the midrib section.

If the inner cells of this section are now considered partly filled with a liquid, a gradual increase in their hydrostatic pressure will straighten and hence spread the closed lobes. This duplicates the action of a Bourdon gauge due to an increase in its internal hydrostatic pressure.

If the motion of the lobes is attributed to the tendency of the diffusion pressure deficits of the inner cells to attain a steady state these must therefore possess the necessary and sufficient attributes to function as elongated circular or quasi-elliptical structures whose longitudinal axes must straighten as their hydrostatic pressures rise,. to counteract the stresses of the normally bent framework of the lobes when closed.

Conversely a decrease of the hydrostatic pressure will reduce the effective normally directed internal forces so that the opposing elastic forces of the fibers in the supporting frame predominate. These curl the frame back into its original configuration.

If the hydrostatic pressure in the Bourdon gauge is reduced rapidly enough the gauge snaps back into its curved position with great speed.

This stimulates the first phase of the closure movements of *Dionaea*. It is, however, impossible to release the hydrostatic pressure of osmotically functioning cells with sufficient rapidity to account for the speed of closure. Hence the cause of the rapid release of the internal pressure must be attributed to a structural change in the interfaces of some cells so as to produce the necessary rapid turgor pressure changes.

A sudden depolarization of the inner specialized layer of epidermal cells with the accomanying change in the hydrostatic pressure which maintains the lobes in their distended positions could be a necessary and sufficient mechanism to account for the closure movements.

It is hoped that the plant physiologist can establish that such an actuated irritable tissue mechanism exists, which allows the inner epidermal cells to drain their fluids into the neighboring intercellular spaces so as to establish the necessary hydrostatic gradient to fulfill the underlying mechanical principles involved in the motions of the lobes of *Dionaea*.

The author takes this opportunity to express his appreciation to Dr. L. A. Whitford, Department of Botany of the North Carolina State College of Agriculture and Engineering at Raleigh, for supplying many beautiful specimens, photographs, and sections of *Dionaea*, and to J. Stanley Johnson for assistance in the calculations of the equipotential fields.

SUMMARY

When the trap of *Dionaea muscipula* had been excited to closure, the recovery or opening movements are independent of the normal processes producing movements of the lobes due to growth. At constant temperature the change in the intensity of light did not affect the basic recovery motion. Frictional factors introduced by the presence of occasional interlocking marginal spines was avoided by clipping away the spines near their bases. Opening speeds of individual lobes are controllable. The lobe which is excited to produce closure does not recover so rapidly as the unexcited lobe. Symmetric opening can only be attained if symmetric closure movements preceded the recovery movements. Speeds of recovery from repeated closures decrease, depending on degree and order of excitation and the trigger-hair pattern that was used to stimulate the excitatory process producing closure.

Closure was analyzed with a moving-picture camera at a speed of 16 frames per second. Angular closure and the vertical aspect of the closing of the edges of the trap showed that the decrease in angular separation and the linear distance between the margins of the lobes were directly proportional to the square of the time. The basic movements are representable by the classical motion of a rigid body rotating about a vertical axis under

the action of constant normally directed forces. The forces maintaining the trap in its open or distended position can be attributed to the action of an internal hydrostatic pressure localized in the layers of cells forming the inner epidermis.

Speed and symmetry of closure can be controlled by the pattern of excitation used to stimulate. A hypothetical excitatory wavefront is derived to show how its action could account for the pattern and speeds of closure. The spreading speed of the excitatory process was determined as about 5 cm. per sec. in young, green plants. As the leaves age the speed of successive closures decrease and recovery is never a completely reversible phenomenon. A hydrostatic analogue in the form of the response mechanism of the Bourdon gauge, is proposed as possessing the necessary and sufficient properties to account for all the mechanical motions. It is suggested that a depolarization of the interfaces of the hydrostatic cells of the inner epidermis can account, on physical grounds, for this sudden reduction in hydrostatic pressure which allows the lobes to collapse as if they were trap doors connected by a flexible hinge swinging under the action of a constant torque.

DEPARTMENT OF PHYSICS, UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, NORTH CAROLINA

Literature Cited

1. **Lloyd, F. E.** The carnivorous plants. Chronica Botanica Company. Waltham, Mass., 1942.
2. **Solereder, H.** Systematische Anatomie der Dicotyledonen. Stuttgart, 1899.
3. **Ashida, J.** Studies on the leaf movement of *Aldrovanda vesiculosa*. Mem. Coll. Sci. Kyoto Imp. Univ. B. **9**: 141–244, 1934; **11**: 55–113. 1935. Bot. Mag. Tokoyo **51**: 505–513. 1937.
4. **Batalin, A.** Mechanik der Bewegung der insectenfressenden Pflanzen. Flora **60**: 33–39; 54–58; 105–111; 129–154. 1877.
5. **Brown, W. H.** The mechanism of movement and the duration of the effect of stimulation on the leaves of *Dionaea*. Am. Jour. Bot. **3**: 68–90. 1916.
6. **Munk, H.** Die electrischen und Bewegungserscheinungen am Blatte der *Dionaea muscipula*. Arch. Anat., Physiol. Wiss. Med. **1876**: 30–203.
7. **Bose, J. C.** An automatic method for the investigation of transmission of excitation in *Mimosa*. Phil. Trans. Roy. Soc. B. **204**: 63–97. 1914.
8. **Darwin, C.** Insectivorous plants. London, 1875.
9. **Burdon-Sanderson, J.** Note on the electrical phenomena which accompany stimulation of the leaf of *Dionaea miscipula*. Proc. Roy. Soc. **21**: 495–496. 1873.
10. **Lorenz, H.** Theorie der Röhrenfedermanometer. Zeits. Ver. Deuts. Ing. **54**: 1865–1867. 1910.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, NO. 1, PP. 45–50 JANUARY, 1948

THE GROWTH-PROMOTING ACTION OF BACTERIA-FREE CROWN-GALL TUMOR TISSUE[1]

R. S. DE ROPP[2]

Production of plant hormones in galls generated by *Phytomonas tumefaciens* has been reported by several workers (Link, Wilcox & Link 1937; Locke, Riker & Duggar 1937, 1938, 1939; Riker, Henry & Duggar 1941). Locke, Riker and Duggar (1938) discovered five types of response shown by plants inoculated with *Ph. tumefaciens*, all of which might be attributed to the formation of growth substances in the galls. These reactions were epinasty of leaf petioles, initiation of adventitious roots, stimulation of cambium, inhibition of growth of lateral buds, and delay of petiole abscission. Subsequent study substantially confirmed these results (de Ropp 1947c) and showed that, when tumor tissue is grafted to normal stem tissue, a type of proliferation frequently results resembling that induced by high concentration of indole acetic acid. The experiments here described were undertaken to throw more light on the nature of the substance producing these effects.

Materials and Methods. Stem tissue of *Helianthus annuus L.* which had been rendered sterile by removal of the epidermis was used as the test object in these experiments. The mode of preparation of this tissue has been previously described (de Ropp 1947b). It was hoped that, by using normal stem tissue as a test object, effects might be observed which would not be detectable by the use of such test objects as the *Avena* coleoptile. The strains of tumor tissue used in this work had the following origins: H_{13}, sunflower tumor tissue isolated from a secondary tumor in 1941 (White & Braun 1942), P_I and P_{II} sunflower tumor tissue isolated from primary tumors of sunflower (de Ropp 1947d), K_I sunflower tumor isolated from an induced tumor in an *in vitro* graft (de Ropp 1947c), V_{60} periwinkle tissue isolated from a gall on *Vinca rosea* which had been freed of bacteria by heat treatment (Braun 1943, White 1945).

An estimate of the weight of the normal stem fragments at the beginning of the experiment was obtained by taking a sample of the stem fragments at random, weighing, and calculating the means. After treatment with the material to be tested, the stem fragments were cultured on standard nutrient

[1] This work was done in part under an American Cancer Society grant recommended by the National Research Council Committee on Growth.

[2] I am indebted to Miss E. Pieczur for technical assistance in connection with this work.

agar at a temperature of 25° C in continuous light provided by fluorescent lighting units. At the end of this period, the fragments were removed and the individual fresh weights and collective dry weights of the fragments in each group were estimated. Each treatment usually contained 20 replicates. The variability of response of the stem fragments was found to be very large and for this reason the fresh weights have been partitioned between different weight classes and the significance of differences determined by use of the chi squared test.

Results. (a) *Direct Grafting.* Tumor tissue of strains H_{13}, P_I, P_{II}, K_I was grafted onto sunflower stem fragments. Normal sunflower stem tissue was similarly grafted as a control. At the end of the four-week growing period the grafts which had taken were removed from the culture tubes and the scion was separated from the normal stock. These stocks were then weighed. The frequency distribution of the fresh weights is shown in table 1.

TABLE 1. *Effect of grafting to normal or tumor tissue on the fresh weights of sunflower stem fragments grown on nutrient agar for four weeks at 25° C.*

Scion	Weight class (mg.)						
	0–50	50–100	100–150	150–200	200–250	250–300	Total
Ungrafted	4	16	0	0	0	0	20
Normal	5	10	0	0	0	0	15
H_{13}	0	6	6	3	0	0	15
P_I	0	2	6	3	3	2	16
P_{II}	0	3	3	2	0	0	8
K_I	0	4	5	0	6	4	19

There is no significant difference in frequency distribution between the stem fragments to which the scion of normal stem tissue was grafted and those stocks which were left ungrafted. From this it appears that no growth-promoting factor passed from the scion into the stock. Those stocks to which tumor tissue was grafted, however, had weights the frequency distribution of which differed in a highly significant manner from that of the stocks grafted to normal tissue. On 17 of the 19 grafts made with strain K_I, secondary tumors were observed at the point of junction of stock and scion. These tumors were removed before the weights were assessed. The presence of the tumor scion also had a significant effect on root production in these grafts. Root production occurred on all the stocks grafted to tumor tissue but only on three of twenty in the ungrafted group and four of fifteen in the group grafted to normal tissue. This experiment, therefore, confirms previous findings and shows that, when normal tissue is grafted to tumor tissue, a factor passes from the tumor scion into the normal stock capable of enhancing growth in the normal tissue which results in a significant increase in the weight of the latter. When normal tissue was used as the scion, no such effect was observed.

(b) *Separation of Normal and Tumor Tissue by Agar Block.* These experiments were designed to determine whether any growth-promoting factor present in tumor tissue was capable of diffusing through a block of agar and of influencing the growth of a fragment of normal sunflower stem placed in contact with the opposite face of the agar. Blocks of sterile 1% agar were prepared by pouring the agar into a petri dish to give a layer of agar of approximately 4 mm. in thickness. Blocks of this agar about 5 mm. square were removed aseptically and placed upright on the surface of slopes of nutrient agar. In contact with one surface of the agar block was placed the cut surface of a fragment of tumor tissue. On the opposite side of the block was placed the cut end of a fragment of normal tissue. Tumor and normal tissue were thus separated by a 4 mm. thickness of agar. In the control group normal sunflower stem tissue was used in place of tumor tissue. The preparations were incubated for a period of 4 weeks at the end of which time the normal tissue was removed and weighed. The frequency distribution of these weights is shown in table 2.

TABLE 2. *Fresh weights of normal stem fragments separated from tumor tissue by agar block after four weeks' culture at 25° C.*

Treatment	Weight class (mg.)					
	50–60	60–70	70–80	80–90	90–100	Over 100
Agar only	5	3	0	0	1	2
Normal tissue	0	1	4	4	5	1
P_I	1	2	4	3	3	5
P_{II}	2	3	6	3	1	1
H_{13}	2	2	4	1	1	1

To determine the significance of differences observed in this table, the values for weights of stem tissue grown in the presence and absence of tumor tissue can be summed to give the following 2×6 contingency table.

Treatment	Weight class (mg.)						
	50–60	60–70	70–80	80–90	90–100	Over 100	Total
Tumor tissue absent	5	4	4	4	6	3	26
Tumor tissue present	5	7	14	7	5	7	45
Total	10	11	18	11	11	10	71

The value of χ^2 as calculated from this table is 4.09121 which corresponds to a value for P of approximately 0.5 for 5 degrees of freedom. This indicates that the tumor tissue when separated from normal tissue by a block of agar

exerts no significant effect on the growth of the normal tissue. The growth-promoting factor, the existence of which was demonstrated in the previous section, does not appear to possess the capacity to diffuse through agar.

(c) *Extracts of Tumor Tissue.* These experiments were designed to test the effect of adding extracts of tumor tissue to the medium on which fragments of normal stem tissue were grown. In the first experiment of this group, the juice of tumor tissue of strains P_1, K_1, H_{13} and V_{60} was expressed aseptically. This juice was dropped in 0.5 ml. amounts onto fragments of sunflower stem tissue on nutrient agar. As a result of the treatment, the fragment itself was covered with the juice of tumor tissue and the agar in the vicinity of the fragment saturated with it. As a control juice was expressed from normal sunflower stem tissue which had been rendered sterile by the removal of the epidermis. The juice was applied to the stem fragments to be tested in the same way as the tumor tissue extract. After 4 weeks of growth under these conditions, the stem fragments were removed and their fresh weights determined. The frequency distribution of these weights is shown in table 3.

TABLE 3. *Distribution of fresh weights of stem fragments cultured for four weeks in the presence of extracts of normal and tumor tissue.*

Treatment	Weight class (mg.)						
	30–40	40–50	50–60	60–70	70–80	80–90	Over 90
No extract	2	5	2	3	4	1	3
Normal tissue	0	6	2	2	3	3	2
P_1	1	4	0	3	4	2	5
K_1	2	2	5	4	3	1	2
V_{60}	1	5	3	1	7	1	1
H_{13}	1	5	4	5	2	0	3

This distribution may be simplified by summing frequencies in the group treated with tumor tissue extract and those treated with normal tissue or left untreated. This gives the following 2×7 contingency table.

	Weight class (mg.)							
	30–40	40–50	50–60	60–70	70–80	80–90	Over 90	Totals
Tumor extract absent	2	11	4	5	7	4	5	38
Tumor extract present	5	16	12	13	16	4	11	78
Totals	7	27	16	18	23	8	16	115

This table gives a value for χ^2 of 3.7144 which with 6 degrees of freedom corresponds to $P = 0.7$. This shows that the extracts of tumor tissue were

without any significant effect on the growth of the fragments of normal stem tissue.

With a view to preventing enzymatic reactions within these extracts, further experiments were performed in the first of which the tumor tissue was heated to the temperature of boiling water for one minute before being ground and in the second the extract was similarly heated immediately after being ground. The summarized data of these experiments is shown in table 4.

TABLE 4. *Distribution of fresh weights of stem cultures treated with heated extracts of tumor tissue after four weeks' culture at 25° C.*

	Weight class (mg.)							
	30–40	40–50	50–60	60–70	70–80	80–90	Over 90	Total
Tumor extract present	4	3	5	11	5	3	3	34
Tumor extract absent	4	12	13	13	5	4	5	56
Totals	8	15	18	24	10	7	8	90

This gives a value for χ^2 of 4.6678 corresponding to a probability of about 0.6 which shows that the heat treatment of the extracts did not alter their effect on the growth of these fragments.

SUMMARY AND CONCLUSIONS

Evidence that crown galls give rise to growth-promoting substances capable of causing epinasty of petioles and initiation of roots has been established beyond reasonable doubt (Locke, Riker & Duggar 1938; de Ropp 1947a). The data in this paper indicate that a factor capable of inducing growth in excised fragments of sunflower stem tissue will pass from tumor to normal tissue, provided that the two are grafted together. But whatever the nature of this factor it appears that it does not diffuse into agar, nor is it present in an active form in extracts of tumor tissue prepared in the fashion described above. The nature of the growth substance of crown-gall tissue thus still remains undetermined.

THE NEW YORK BOTANICAL GARDEN
NEW YORK

Literature Cited

Braun, A. C. 1943. Studies on tumor inception in the crown-gall disease. Am. Jour. Bot. **30**: 674–677.

De Ropp, R. S. 1947a. The response of normal plant tissues and of crown-gall tumor tissues to synthetic growth hormones. Am. Jour. Bot. **34**: 53–62.

———. 1947b. Sunflower stem cultures for the detection of plant hormones. Nature **159**: 606.

———. 1947c. The growth promoting and tumefacient factors of bacteria-free crown-gall tumor tissue. Am. Jour. Bot. **34**: 248–261.

————————. 1947d. The isolation and behavior of bacteria-free crown-gall tissue from primary galls of *Helianthus annuus*. Phytopathology **37**: 201–206.

Link, G. K. K., Wilcox, H. W. & Link, A. D. 1937. Responses of bean and tomato to *Phytomonas tumefaciens*, *P. tumefaciens* extracts, B-indoleacetic acid, and wounding. Bot. Gaz. **98**: 816–867.

Locke, S. B., Riker, A. J. & Duggar, B. M. 1937. A growth hormone in the development of crown-gall. Phytopathology **27**: 134. (Abstract.)

————————, ———————— & ————————. 1938. Growth substance and the development of crown-gall. Jour. Agr. Res. **57**: 21–39.

————————, ———————— & ————————. 1939. The nature of growth substance originating in crown-gall tissue. Jour. Agr. Res. **59**: 535–539.

Riker, A. J., Henry B. & Duggar, B. M. 1941. Growth substance in crown-gall as related to time after inoculation, cortical temperature, and diffusion. Jour. Agr. Res. **63**: 395–405.

White, P. R. 1945. Metastatic (graft) tumors of bacteria-free crown-galls on *Vinca rosea*. Am. Jour. Bot. **32**: 237–241.

White, P. R. & Braun, A. C. 1942. A cancerous neoplasm of plants. Autonomous bacteria-free crown-gall tissue. 1942 Cancer Research **2**: 597–617.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, NO. 1, PP. 51–55 JANUARY, 1948

THE ORIGIN OF TOBACCOS OF THE ORIENTAL TYPE[1]

FREDERICK A. WOLF AND FREDERICK T. WOLF

Introduction. Throughout our studies of oriental tobaccos during the past eight years we have frequently been asked "What is the original source from which the oriental or Turkish types of tobacco were derived?" It is commonly accepted that all species of *Nicotiana* are of American origin, with the exception of *N. suaveolens* and perhaps a few others that are native to Australia. It also seems well established that tobacco was not mentioned from Europe or Asia until after the discovery of America by Columbus (Garner 1946).

The striking differences between flue-cured, cigar-leaf, Burley, dark-fired, and oriental tobaccos, and also varietal differences within each of these types as they are grown in the field, give rise to some skepticism as to their common origin. If it could be observed that certain oriental varieties and domestic varieties may be grown under conditions in which they come to resemble each other so closely as to be difficultly distinguishable, then the evidence of the same origin of these types would be accepted. During the past season such evidence has indeed been brought to the attention of certain tobacconists, who have expressed their complete accord with the conclusions and interpretations given in the brief considerations that follow.

Materials. Seed of approximately 50 named varieties of oriental tobacco, originating in Greece, Turkey, and Iran, were provided for experimental use during the season of 1947. In early May seedlings of each variety were transplanted into a field at the Tobacco Experiment Station, Oxford, N. C., the plants being spaced 5 inches apart in 20-inch rows. Also in an adjacent plot certain of these varieties were spaced so that the interval between plants was 24 inches in 4-foot rows. Other cultural conditions were quite alike with both spacings. Three of the varieties thus grown bore the varietal names Mavros de Lamia, Argos, and Sari de Almyros. Attention is especially directed to these three varieties because they appear to represent three widely different domestic types, namely flue-cured tobacco, cigar-leaf tobacco, and Burley tobacco respectively.

Observations. It is quite generally appreciated by growers that spacing influences the stature of the tobacco plant. When plants are grown closely

[1] These investigations were financed, in part, by the General Education Board. The cultivation of oriental tobacco is being studied cooperatively by the Department of Botany and the Department of Chemistry, Duke University, and the North Carolina State Department of Agriculture. Grateful acknowledgment is made for the whole-hearted cooperation of E. G. Moss, Tobacco Experiment Station, Oxford, N. C.

spaced, the outcome is decreased size, maximum size being reached only when ample distance between plants is provided. Little is known, however, about the dissimilarities induced by spacing other than the fact that physical differences or gross morphologic differences are produced. In the present observations with the above-mentioned varieties such differences are portrayed by measurements of plant and leaf size, as shown in table 1.

It is plainly evident from table 1 that each variety responded by production of plants having larger stature and larger leaf sizes at the larger interval of spacing. Proportion or balance between stem dimensions and leaf dimensions of each variety, although not directly shown, was apparently maintained. Supportive evidence for this conclusion, as regards the leaves, is shown photographically in figures 1, 2, and 3, representing Mavros de Lamia, Argos, and Sari de Almyros, respectively.

TABLE 1. *Comparison of gross features of certain oriental varieties of tobacco when grown at different spacing intervals.*

Variety	Height of plants (cm.)		Average leaf area of plants ($cm.^2$)		Leaf length × leaf width of plants (cm.)	
	Closely spaced	Widely spaced	Closely spaced	Widely spaced	Closely spaced	Widely spaced
Mavros (black or dark) de Lamia	45	120	144	562	23 × 8	46 × 16
Argos	56	140	167	1042	22 × 12	46 × 28
Sari (yellow) de Almyros	55	100	160	475	16 × 7	34 × 18

From these data and photographs it remains difficult, however, to visualize the similarities and differences that meet the eye when these varieties are seen in the field. For example, to anyone familiar with domestic types of tobacco, Sari de Almyros is undoubtedly the well known variety, White Burley, whether it is seen in the seedbed, or whether observed in closely spaced rows or in widely spaced rows in the field. Furthermore Mavros de Lamia is one of the well known flue-cured varieties known as Lizard's Tail, that formerly was rather widely grown in Virginia. It may be readily identified when grown in widely spaced rows. Argos, on the other hand, is some cigar-leaf variety. We are unable however, to identify Argos among named domestic varieties of cigar-leaf tobacco, because of lack of familiarity with them. It is of more than passing interest to relate that our opinion of the identity of this variety is supported by the experience of a dealer[2] who offered a quantity of Argos grown in Macedonia to several manufacturers of blended cigarettes. These manufacturers refused the tobacco for the

[2] Private communication.

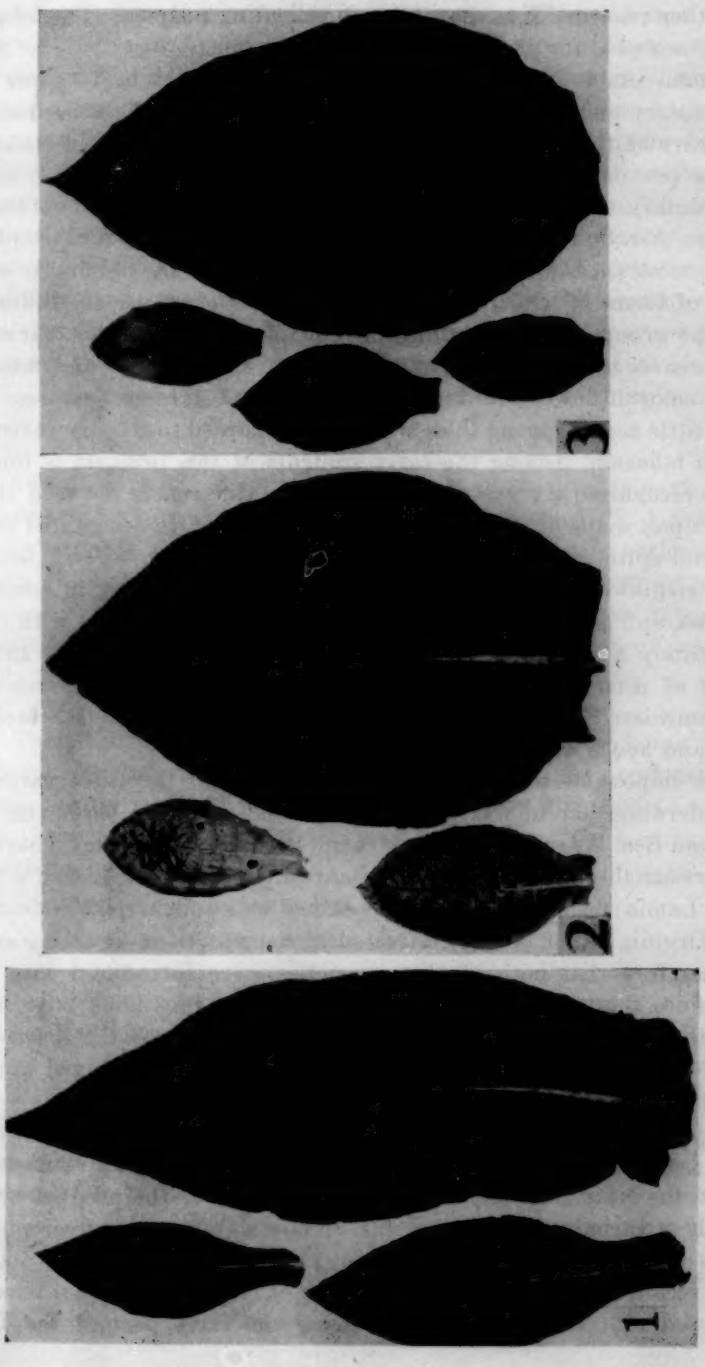


FIG. 1. At left, two average sized leaves of Mavros de Lamia (Lizard's Tail) tobacco, at right, a leaf that is typical of Lizard's Tail, a flue-cured variety. Note comparative sizes. FIG. 2. Appearance of Argos. At left, 2 typical leaves when grown as an oriental tobacco, at right, a leaf when grown as a cigar-leaf type. The sizes are comparative. FIG. 3. Appearance of oriental Sari de Almyros (White Burley) when grown as an oriental tobacco, at left, and when grown as a Burley type, at right.

reason that they regarded it as unsuitable for blending purposes. The tobacco was however accepted for use by a cigar manufacturer.

Discussion. As is generally known, genetical studies bearing on the origin of ordinary tobacco and of other species of *Nicotiana* have been made in recent years at the University of California. The results of certain of these studies (Setchell, Goodspeed & Clausen 1922; Goodspeed 1933) indicate that ordinary tobacco may well be a natural hybrid, resulting from a cross between *Nicotiana sylvestris* and some member of the *N. tomentosa* group. If *N. tabacum* is a hybrid, then a basis exists for the seemingly endless variety of forms of which it is composed, as evidenced by the different domestic type groups, each containing a multiplicity of different varieties having differences in stature, in leafiness, in size, shape, color, and texture of leaves, in color of flowers, in date of flowering, and in other features.

There is little accord among those who have attempted to classify varieties of *Nicotiana tabacum*. Among the early students of this problem is Comes (1899) who recognized six primary varieties, the differences between them being based upon shape of leaf and character of corolla. He designated them by the varietal epithets *brasiliensis, fruticosa, havanensis, lancifolia, macrophylla,* and *virginica.* Geneticists have experienced no difficulty in crossing these varieties, and furthermore ordinary tobacco has been crossed with each of approximately a score of other species of *Nicotiana* (Goodspeed 1933). The subject of intervarietal and interspecific hybridization of tobacco is succinctly considered by Garner (1946) in a recent volume *The Production of Tobacco* and hence will not be further discussed.

It is now impossible to determine when any one of the three varieties under consideration herein was first grown in the countries bordering the Mediterranean Sea. As indicated by Garner (1946) White Burley (Sari de Almyros) presumably originated as a mutant in Ohio in 1864. Lizard's Tail (Mavros de Lamia) has been largely supplanted as a commercial flue-cured variety in Virginia but it is still cultivated in some sections. It seems quite probable therefore that both of these varieties were introduced into the Near East since the turn of the century. Similarly Argos must have been introduced there recently. At any rate none of them possesses the characteristics of a good-quality oriental tobacco and none has been changed appreciably in response to the environment of the Mediterranean region.

Quite a different situation obtains, however, as regards the oldest, best known, and best established kinds of oriental tobacco now being extensively cultivated in the Near East and constituting the bulk of the product being exported. These varieties do not resemble, to any significant degree, any of the varieties of any domestic types now being cultivated in the United States. It should be recalled, in accounting for this lack of resemblances, that tobacco was introduced into Turkey and Iran during the early part of the 17th

century. During this period of approximately 300 years many changes in characteristics could have been wrought in the Near East, and it is quite certain that present day kinds under cultivation in the United States are unlike those grown by the early settlers. The differences between oriental types and domestic types are such as might result from hybridization, selection, and environmental factors operating over a maximum period in excess of 300 years in each region or perhaps a totality of 600 years in either region alone. This conclusion, as regards oriental tobaccos, accords with Nestoroff (1928) who stated that their origin is now quite completely lost and they must be placed in a class by themselves. All evidence indicated to him that the original kinds came from America but many new kinds having features that are fundamentally different from the original kinds had come into existence as the result of many crosses and of adaptative changes.

Summary

Seed originating from certain varieties of oriental tobacco in the Mediterranean region, when planted and grown in the United States, produce kinds that are recognizable as identical with domestic varieties at present being cultivated in this country. A representative variety of each of three domestic types has been thus recognized. Each one was apparently introduced from the United States into the Near East in recent years. These results constitute evidence that oriental tobaccos originated in the Americas and that means are still at hand to prove their origin.

Varieties that cannot be identified with kinds now being cultivated in tobacco-growing regions of the United States may be presumed to have become greatly modified in response to hereditary and environmental factors that have acted throughout the long period from their early introduction in the Near East.

Department of Botany, Duke University
Durham, North Carolina
and
Department of Biology, Vanderbilt University
Nashville, Tennessee

Literature Cited

Comes, O. 1899. Monographie du genre *Nicotiana* comprenant le classement botanique des tabacs industriels. Atti R. Inst. Incoraggiamento Napoli V. 1. 80 p.

Garner, W. W. 1946. The production of tobacco. XIII + 516. Philadelphia.

Goodspeed, T. H. 1933. Chromosome number and morphology in *Nicotiana*. Proc. Nat. Acad. **19**: 649–653.

Nestoroff, Marco. 1928. The oriental tobaccos. Vol. 1, 250 p. Dresden.

Setchell, W. A., Goodspeed, T. H. & Clausen, R. E. 1922. Inheritance in *Nicotiana tabacum*: I. A report on the results of crossing certain varieties. Univ. Calif. Publ. Bot. **5**: 457–582.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, NO. 1, PP. 56–115 JANUARY, 1948

PLANT EXPLORATIONS IN GUIANA IN 1944, CHIEFLY TO THE TAFELBERG AND THE KAIETEUR PLATEAU—I.[1]

BASSETT MAGUIRE AND COLLABORATORS

Since the early journeys and collections of Schomburgk, the Guyana Highland has become increasingly recognized as a region of considerable botanical complexity, diversity, and antiquity. Over a long period, as successive explorations of the lofty dominating sandstone mesas, Roraima, Duida, and Auyantepui progressed, great numbers of new species and genera were uncovered, revealing a vast, hardly touched phytogeographic province where apparent endemism on the isolated block mountains is incredibly high.

More recently, Duida and Roraima have been revisited and the plants of another mountain, Ptari-tepui, collected by Dr. Julian A. Steyermark of the Chicago Natural History Museum (Speciation in the Venezuelan Guyana. Am. Jour. Bot. **34**: supplement 29a. 1947. [Abstract.])

Within the last year still another high plateau, Cerro Yaví, has been explored by William H. Phelps, Jr., who has achieved such spectacular results in the collection and study of the avi-fauna of the numerous sandstone mountains of the Guyana Highland. No one else has carried on scientific exploration in this important region so continuously and successfully as he. A collection of plants made from Cerro Yaví by Mrs. Phelps and Charles B. Hitchcock is now under study in Caracas and New York.

During 1944 the New York Botanical Garden undertook the exploration of the most eastern and farthest isolated of the block mountains, Tafelberg, in central Surinam, lying at the headwaters of the Saramacca and Coppenam Rivers. Tafelberg, although perhaps seen by early explorers, was discovered,[2] recognized in its true significance, and visited in 1926 by Professor Gerold Stahel, eminent botanist and agriculturist of Dutch Guiana.

To better interpret the flora of Tafelberg and to correlate it with that of the Guyana Highland far to the West, a short period of study and collection was spent on the Kaieteur Plateau by D. B. Fanshawe, forest officer in British Guiana, and me.

[1] This report will appear in six parts. The cost of the pages in excess of those ordinarily accepted from one contributor is met by the New York Botanical Garden.

[2] For a discussion of the history of discovery of Tafelberg and the itinerary of the Garden's 1944 explorations, see the written accounts: "Notes on the geology and geography of Tafelberg, Suriname." Geogr. Rev. **35**: 563–579. 1945; "The first Botanical Exploration of Table Mountain in Surinam." Jour. N. Y. Bot. Gard. **46**: 253–272, 277–287. 1945.

In all, more than 2300 collections were made, some 775 in British Guiana and the remainder in Surinam. In addition, numerous collections separately made by Fanshawe have been studied. It is proposed to report on the botanical results of these collections in a series of papers, of which this is the first. Specialists whenever available have been called upon to review the material of their interest. Their findings appear under the reviewer's own name. In the final paper, it is hoped to summarize an evaluation of the ecology and phytogeographic significance of floras of Tafelberg and the Kaieteur Plateau.

It is my pleasant duty to make grateful acknowledgment to the many who have been instrumental in making the exploration possible, and to those who have participated in the study of the collected materials.

Financial support was generously given by the John Simon Guggenheim Memorial Foundation, the American Philosophical Society, Mr. Pierre Jay of New York and the New York Botanical Garden.

In British Guiana, the field study was skilfully planned and directed by Mr. D. B. Fanshawe, who in his own right is a competent botanist and who has profound and intimate knowledge of the Guianan flora. The cooperation of the Forestry Department and the assignment of its trained field crew brought results far beyond that which might have been expected from so short a visit to British Guiana.

The Tafelberg expedition could not have accomplished its purpose but for the unstinted help given to us by all in Surinam (Dutch Guiana). To His Excellency, the Governor, to the many officials of the Surinam Government, and particularly to Dr. D. C. Geijskes and Mr. F. H. Schols, grateful acknowledgment is made for assistance and encouragement.

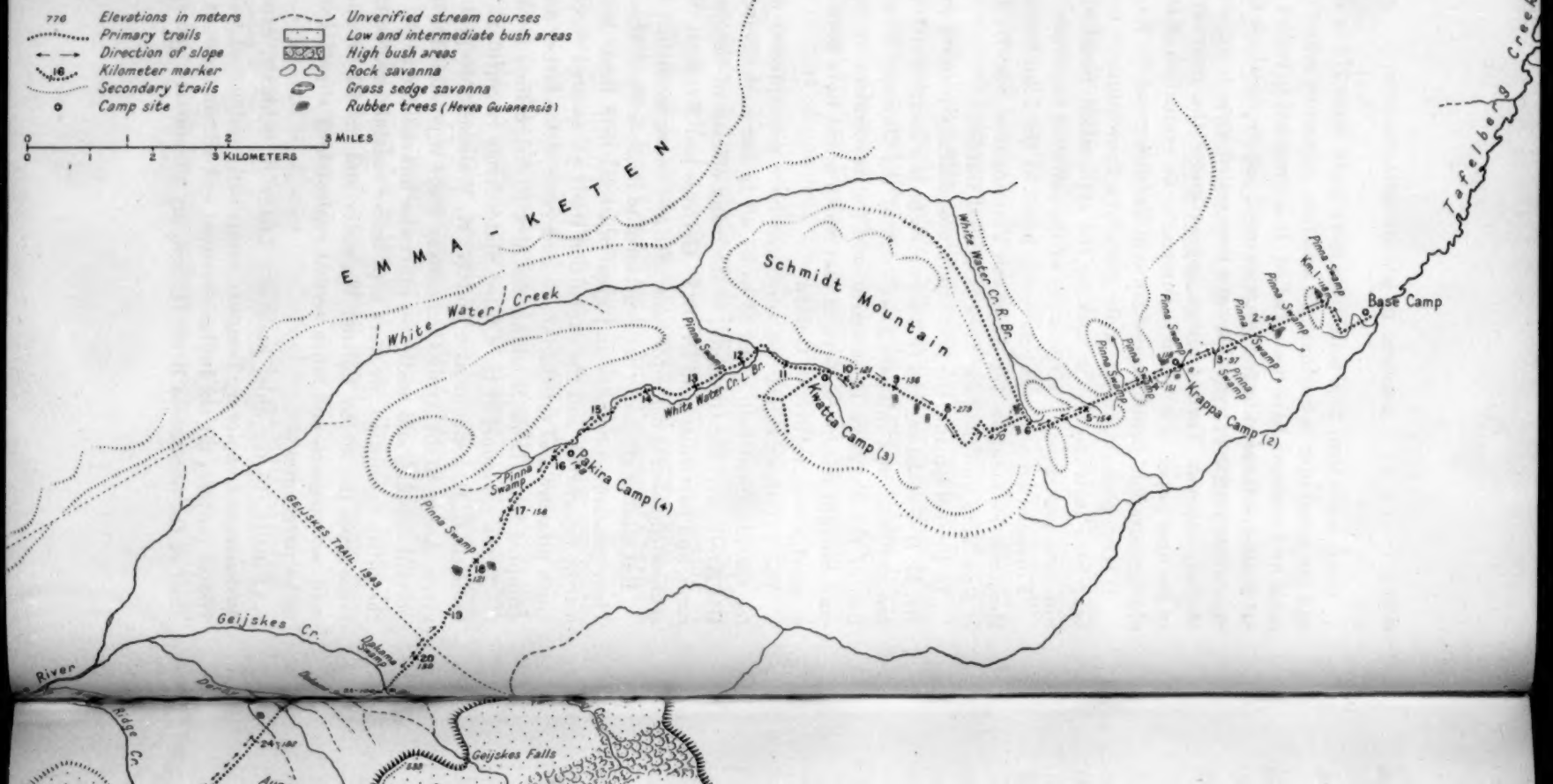
But most of all the writer is grateful to Professor and Mrs. Gerold Stahel. Their gracious courtesies and great material help made my stay in Paramaribo delightful, and the expedition itself an assured success. It gave me much pleasure and satisfaction to name one of the larger and lovelier falls dropping from Table Mountain for Mrs. Stahel, calling it Lisa Falls.

To the personnel of the United States Army in Surinam, particularly to Colonels L. H. Schonnmaker and W. W. Walmsley, deepest appreciation is given. Access to the Army Commissary made it possible for us to obtain important supplies and medicines otherwise unavailable in the colony. During the entire expedition, we were kept under constant and comforting surveillance from the air by Colonel Walmsley and his fellow pilots. Repeatedly mail, newspapers, and much-needed replenishing supplies were dropped to us by parachute.

Finally, to my chief assistant, Lodewijk Schmidt, experienced native bushman and explorer; Tempico, competent headman of our crew of Carib Indian porters; the six Indian carriers; and Elmond, son of the bush negro chief of the Saramacca River Djukas, my affectionate thanks are given. All

TAFELBERG
SURINAME

HE NEW YORK BOTANICAL GARDEN TROPICAL EXPEDITION, 1944



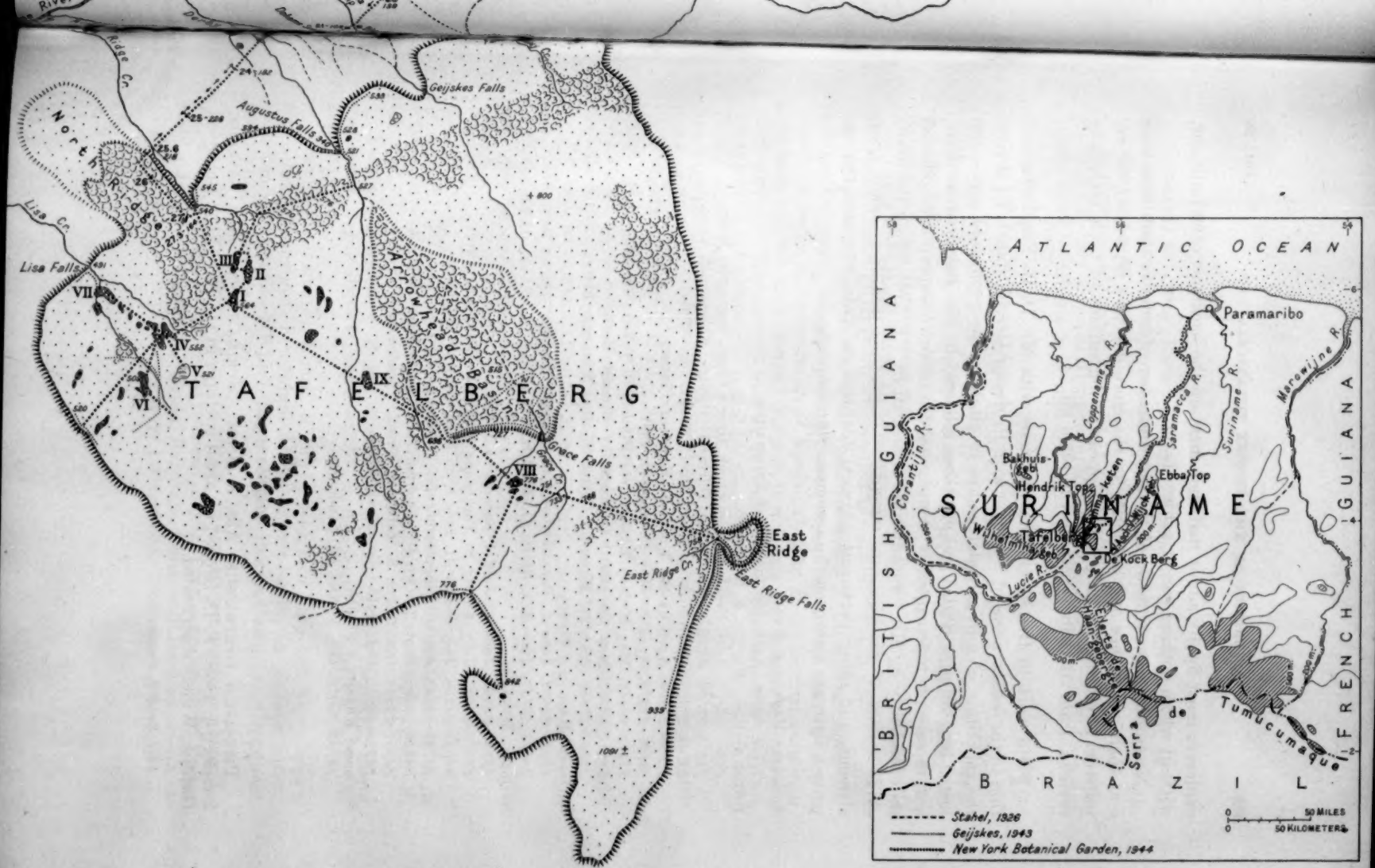


FIG. 1. Map of Tafelberg and approach. (Published by permission of the American Geographical Society.)

explorers must finally admit that such men are the backbone of expeditions, without whom nothing can be achieved.

No enumeration is made of the large number of collaborators who have lent their experience and authority to the more effective report on the expedition's collections. Their names appear as the authors of their respective reviews. I am admiringly grateful to them all.

Field work in British Guiana was done with Mr. D. B. Fanshawe, and that in the coastal areas of Surinam with Professor Gerold Stahel. To obviate the repetition of our personal names in citation, the numbered series collected by Professor Stahel and me, those collected by Mr. Fanshawe and me, and those made independently by me are given below. All specimens collected independently by Mr. Fanshawe are indicated by "F" preceding the exsiccatae numbers, for example "F2059." Collecting localities, camp sites, streams, and other pertinent physical features on Tafelberg and the approach to it, are shown on the accompanying map (fig. 1).

Surinam: *Maguire & Stahel.*
22707–22806. April 3–8. vicinity of Paramaribo.
British Guiana: *Maguire & Fanshawe.*
22807–22952. April 13–21. Kamuni Creek, Groete Creek, Essequibo River.
22953–23004. April 25–26. Bartica-Garraway Stream, Kangaruma Road.
23005–23049. April 26–27. Potaro River, Kangaruma—Tukeit.
23050–23094. April 28–29. Tukeit to Kaieteur Plateau.
23095–23472. April 30–May 15. Kaieteur Plateau.
23473–23556. May 16–May 19. Kaieteur Plateau to Tukeit; Kaieteur Gorge.
23557–23561. May 20—Bartica—Garraway Stream Road.
23562–23582. May 23. Mazaruni Forest Station, Mazaruni River.
Surinam: *Maguire & Stahel.*
23583–23602. June 2. Paramaribo—Carl Francois Road.
23603–23737. June 3–4. Sectie O, Zanderij.
Surinam: *Maguire.*
23738–24065. June 12–July 4. Saramacca River.
24066–24087. July 4–July 8. Toekoemoetoe Creek—Tafelberg Creek.
24088–24196. July 8–July 31. Line from Base Camp to Tafelberg.
24197–24817. August 1–September 21. Tafelberg.
24818–24890. Sept. 21–Oct. 4. Line from Tafelberg to Base Camp.
24891–24918. Oct. 5–Oct. 8. Tafelberg Creek, Toekoemoetoe Creek.
24919–24952. Oct. 8–13. Saramacca River.
Surinam: *Maguire & Stahel.*
24953–25072. Oct. 18–Oct. 20. Zanderij.

Fungi[3]

PHYSARACEAE

PHYSARUM COMPRESSUM Alb. & Schw. SURINAM: east side, savanna, Zanderij I. *25055 F.* Developed on aroid cuttings in the New York Botanical Garden. Widely distributed.

[3] By Fred J. Seaver.

PEZIZACEAE

COOKEINA SULCIPES (Berk.) Kuntze. SURINAM: on rotten wood, in open high bush, base of north escarpment, Tafelberg, *24312 F.* Common throughout the tropics of the world.

MELASTIZA ASPERRIMA (Ellis & Ev.) Seaver. SURINAM: pina swamp, vicinity Kwatta Camp (3), Coppenam River Headwaters, *24149 F.* Formerly known from Nicaragua to Mexico and the West Indies.

XYLARIACEAE

XYLARIA CUBENSIS Mont. SURINAM: on decaying wood, in montane forest, line beyond Pakira Camp (4), Coppenam River Headwaters, *24168 F.*

XYLARIA DENDROIDEA Cooke & Massee. (Fig. 2.) SURINAM: locally common on fallen decaying log, montane forest, vicinity Krappa Camp (2), Saramacca River Headwaters, *24145F;* on decorticated log, vicinity Kwatta Camp (3), Coppenam River Headwaters, *24148 F.* Specimens were sent to Dr. David Linder of Harvard who replied as follows: "Thank you very much for the beautiful specimen of what you have called *Xylaria dendroidea* Cke. & Mass. On seeing this specimen I looked in our herbarium and there it is under the name of *Thamnomyces Chamissonis* Ehr. It is identical with your specimen and for that reason I suspect that Cooke and Massee's name is a later synonym. The material that we have also comes from Surinam, although the type of *Th. Chamissonis* is said by Saccardo to have been described from Brazil, a fact that would not be surprising since the Guianas merge more or less with Brazil as the hinterland and mountains slope downwards towards the east."

XYLARIA GRAMMICA Mont. SURINAM: on fallen log, vicinity Krappa Camp (2), Saramacca River Headwaters, *24144 F.*

XYLARIA GUIANENSIS Mont. SURINAM: on decaying wood, high mixed wallaba forest, south base of Table Mountain, km. 24.5, *24830 F.*

XYLARIA MULTIPLEX (Kunze) Berk. & Curt. SURINAM: on decorticated log, below west escarpment, Tafelberg, *24681 F.*

XYLARIA sp. *24193 F, 24264 F, 24550 F,* and *24630 F* are all sterile, and some may be sterile forms of *X. dendroidea.*

POLYPORACEAE

FOMES AUSTRALIS (Fries) Cooke. SURINAM: locally common, in high forest, base south escarpment, Arrowhead Basin, Tafelberg, *24509 F, 24618 F.*

FOMES PSEUDOSENEX Murr. SURINAM: bracket, tawny beneath, along east-facing slopes above escarpment, 300 meters south of East Ridge, Tafelberg, *24551 F.*

POLYPORUS ALBOGILVUS Berk. & Curt. SURINAM: bracket, rusty-brown above, white-margined, hymenium becoming pubescent, in wallaba forest, along line between Black Water Camp (5) and Pakira Camp (4), Coppenam River Headwaters, *24839 F.*

POLYPORUS CORROSUS Murr. SURINAM: yellow-brown, uniform throughout, dakama bush, bottom of Arrowhead Basin, Tafelberg *24616 F.* Previously known from southern Florida, Bahamas, Cuba, and Jamaica.

POLYPORUS FULVOCINEREUS (Murr.) Overholts. SURINAM: Posoegronoe,

Saramacca River, *24033 F.* Formerly known from Cuba, Jamaica, Hispaniola, St. Croix, and Barbados.

POLYPORUS LICNOIDES Mont. SURINAM: gold-brown, uniform throughout,

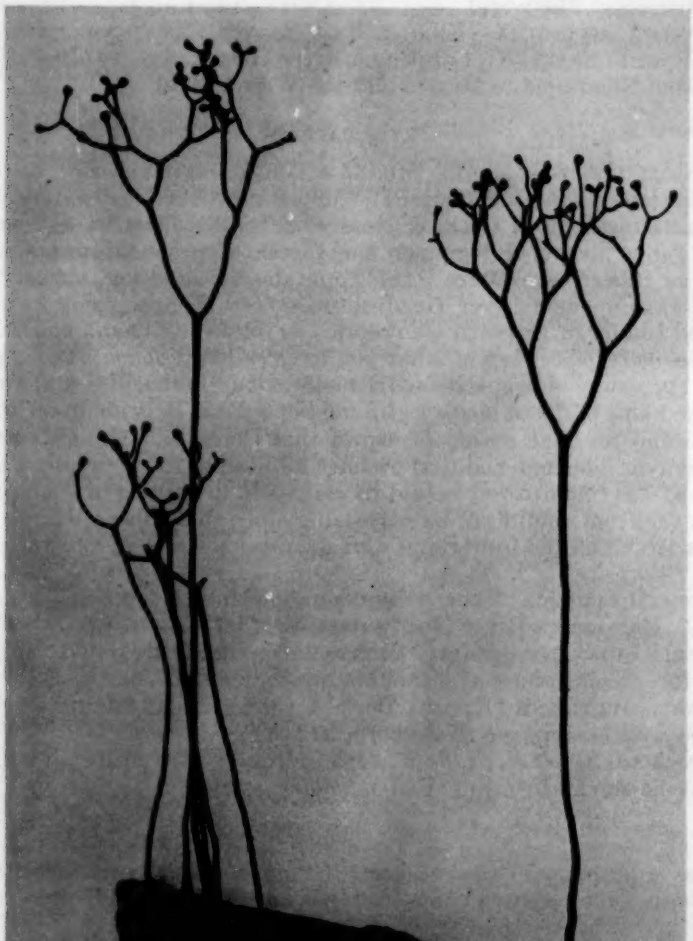


FIG. 2. *Xylaria dendroidea* Cooke & Massee, an unusual and rare fungus of Surinam. *Maguire 24145 F.*

dakama bush, bottom of Arrowhead Basin, Tafelberg, *24615 F.* Previously known from tropical America, the Gulf States, and tropical Asia.

TRICHAPTUM TRICHOMALLUM (Berk. & Mont.) Murr. SURINAM: brown-

ish-purple, on fallen log, montane forests, vicinity Krappa Camp (2), Saramacca River Headwaters, *24138 F.* Central America, Cuba, Jamaica, and South America.

AGARICACEAE

LENTINUS CRINITUS (L.) Fries. SURINAM: on fallen tree, low bush, 1.5 km. west of Savanna IV, Tafelberg, *24411 F.* This species which is very variable in form and consequently described under many names is widely distributed throughout our tropical and subtropical regions.

SCHIZOPHYLLUM COMMUNE Fries. SURINAM: locally common, fleshy, pinkish-white, high forest, base south escarpment, Arrowhead Basin, Tafelberg, *24506 F.* Very common and widely distributed throughout temperate and tropical America.

THELEPHORACEAE

STEREUM DECOLORANS (Berk. & Curt.) Lloyd. SURINAM: stipe varnished, high forest, base south escarpment, Arrowhead Basin, Tafelberg, *24508 F.*

STEREUM HYDROPHORUM Berk. SURINAM: on small tree in low forest, vicinity Kwatta Camp (3), Coppenam River Headwaters, *24151 F.*

HYPOLYSUS MONTAGNEI Berk. SURINAM: west escarpment, Tafelberg, *24680 F.* Widely distributed through the tropics.

CLADONIACEAE

CLADONIA PYCNOCLADA (Pers.) Nyl. *C. falax* des Abb. SURINAM: common under shrubs and border of bush, Savanna I, Tafelberg, *24259 L, 24260 L.*

PARMELIACEAE

POLYSTROMA FERNANDEZII Clem. *Ozocladium Leprieurii* Mont. SURINAM: twigs of living shrub, high forest, base south escarpment, Arrowhead Basin, Tafelberg, *24507 L.* Dr. C. W. Dodge, who determined the species, writes: "In reply to your letter of November 8, I was very glad to receive the specimen of *Polystroma Fernandezii* Clem. (*Ozocladium Leprieurii* Mont.). No one has ever thoroughly monographed this genus of the Thelotremaceae. It is apparently confined to Spain and Guiana and is seldom collected. I saw a specimen while I was at Harvard. Clemente's original description is unavailable, and Montagne failed to find mature spores. It is possible that if the *Polystroma* was described from Spain the Guiana material is a different species. Certainly the finding of the same species in both localities would be very unusual since the morphology is so distinctive everyone has been content to identify their material as this species. We are very glad to have this material for our Herbarium."

USNEACEAE

SIPHULA FASTIGIATA Nyl. SURINAM: locally common, encrusting bed rock, Savanna VIII, Tafelberg, *24509 L.* Dr. C. W. Dodge writes: "As no member of this genus has been found fertile, its systematic position is uncertain. In structure of the thallus, this species closely resembles *Dactylina madreporiformis* (Ach.) Tuck. although it differs in habit and method of branching."

Hepaticae[4]

LEPIDOZIACEAE

BAZZANIA GRACILIS (Hampe & Gottsche) Stephani. SURINAM: on tree, high forest, 100 meters west of Grace Falls, Arrowhead Basin, Tafelberg, *24513 H;* steep east-facing slopes, high forest, 300 meters south of East Ridge, Tafelberg, *24548 H*. The West Indies and South America.

METZGERIACEAE

METZGERIA HAMATA Lindb. SURINAM: on tree in dakama forest, 1 km. northwest of East Ridge, Tafelberg, *24547 H*. Broadly distributed in tropical and temperate regions of the world.

Musci[5]

SPHAGNACEAE

SPHAGNUM PALUSTRE L. SURINAM: south savanna, vicinity Arawak village of Mata, *24986 M;* frequent, wet rocks, high bush, base north escarpment, Tafelberg, *24339 M–1*. Widely distributed in North America, Europe, Asia. This almost cosmopolitan species is not generally credited to South America. It has an extensive synonymy, however, and no doubt appears under other names. The determination has been confirmed by Dr. Andrews.

DICRANACEAE

CAMPYLOPUS FILIFOLIUS (Hornsch.) Mitt. SURINAM: high bush, base south cliffs, Arrowhead Basin, Tafelberg, *24458 M*, in part. Guatemala, Costa Rica, Brazil.

CAMPYLOPUS RICHARDI Brid. SURINAM: frequent, wet rocks, high bush, base north escarpment, Tafelberg, *24339 M–4;* extensive rock and pigmy bush openings, Savanna VIII, *24443 M–2*. Mexico, Central America, West Indies, South America. These collections are sterile, more slender than the typical form, and with the hyaline leaf tips poorly developed, but show the characteristic costal structure and leaf cells.

EUCAMPTODONTOPSIS PILIFERA (Mitt.) Broth. SURINAM: frequent, on tree trunks, bush, Savanna VIII, Tafelberg, *24509 M;* precipitous east-facing slopes above escarpment, 300 m. south of East Ridge, Tafelberg, *24552 M*. West Indies, Trinidad. Not previously recorded from the South American mainland.

LEUCOLOMA SERRULATUM Brid. SURINAM: rocks, high forest, base of south escarpment, Arrowhead Basin, Tafelberg, *24521 M;* common epiphyte on *Clusia* bush, 1 km. west of East Ridge, Tafelberg, *24598 M–1*. Mexico, Central America, West Indies, British Guiana. A frequent species in tropical North America but uniformly sterile in my experience.

LEUCOBRYACEAE

OCTOBLEPHARUM ALBIDUM Hedw. SURINAM: frequent, drying cliffs, west escarpment, Tafelberg, *24679 M*. Pantropical distribution, usually on tree trunks at low altitudes.

---

[4] By Margaret H. Fulford.

[5] By Edwin B. Bartram.

OCTOBLEPHARUM CYLINDRICUM Schp. SURINAM: on *Mauripa,* east side, savanna, Zanderij I, *25059 M*. British Honduras, Dominican Republic, northern South America. Readily distinguished from the ubiquitous *O. albidum* when in fruit by the narrowly cylindrical capsules and longer setae.

LEUCOBRYUM CRISPUM C. M. SURINAM: in low forest, along line between Black Water Camp (5) and Table Mountain, *24193 M;* frequent, high bush, northwest Savanna VIII, Tafelberg, *24434 M–3*. West Indies, northern South America. The slender, crisped leaves give this species a characteristic appearance.

LEUCOBRYUM MARTIANUM (Hornsch.) Hampe. SURINAM: pina swamp, vicinity Base Camp (1), Tafelberg Creek, Saramacca River Headwater, *24119 M;* frequent, wet rocks, high bush, base north escarpment, Tafelberg, *24339 M–1*. Central America, West Indies, northern South America. Readily known by the falcate-secund leaves with the leucocysts in two layers throughout the leaf.

CALYMPERACEAE

SYRRHOPODON PROLIFER Schwaegr. SURINAM: cliffs, drier places, below north escarpment, between North Ridge and Augustus Creeks, Tafelberg, *24186 M* in mixture. Mexico, West Indies, northern South America.

SYRRHOPODON LEPRIEURII Mont. SURINAM: high bush, base south cliffs, Arrowhead Basin, Tafelberg, *24458 M–1*, in part Guiana. A rare and localized species apparently confined to the Guiana region.

CALYMPERES GUILDINGII Hook. & Grev. SURINAM: precipitous east-facing slopes above escarpment, 300 m. south of East Ridge, Tafelberg, *24549 M–2*. West Indies. This is apparently the first record of the species in South America.

Calymperes (*Eucalymperes*) **Maguirei** Bartr. sp. nov. Caespites atro-lutescentes, nitidi. Caules 3–4 mm. alti. Folia conferta, sicca flexuosa, humida stricta, fragilissima, ad 15 mm. longa, e basi oblonga serrulata, 2.5–3 mm. longa anguste lineari-lingulata, acuta, lamina inferne sensim contracta, longe (circa 3 mm.) supra basin evanida; margines incrassato-limbati, ubique minute et remote denticulati; costa infra apicem evanida; cellulae superiores rotundatae, incrassatae, laevissimae, diam. 8–12 μ.

Plants glossy, yellowish in younger parts, becoming dark brown with age. Stems short, 3–4 mm. high. Leaves crowded, flexuous when dry, very fragile, to 15 mm. long, narrowly linear-ligulate from an oblong, serrulate base 2.5–3 mm. long, acute, lamina gradually narrowed below to a stretch of bare costa about 3 mm. long extending to the shoulders of the leaf base; margin thickened forming an opaque border, remotely and minutely denticulate all around; costa strong, triangular in cross-section, prominent at back, ending just below apex, smooth on both sides; cells of lamina smooth, rounded, diam. 8–12 μ; cancellinae well defined, ending in acute angles above with the cells in two layers; teniolae none. Fruit unknown.

TYPE: precipitous east-facing slopes above escarpment, 300 m. south of East Ridge, Tafelberg, Surinam, October 29, 1944, *Maguire 24549 M*. A very singular species closely allied to *C. petiolatum* Bartr. of Fiji but quite distinct in the twice longer leaves with a narrowly linear blade. In habit and appearance *C. Maguirei* closely resembles *C. lonchophyllum* Schwaegr., but the unique leaf structure with the blade contracted to a stretch of bare costa above the basal leaf shoulders is a marked feature shared by only two other species, *C. petiolatum* of Fiji and *C. Ebaloi* Bartr. of the Philippines.

BRYACEAE

RHODOBRYUM BEYRICHIANUM (Hornsch.) Par. SURINAM: frequent, high bush, northwest of Savanna VIII, Tafelberg, *24435 M*. Mexico, Central America, South America.

PHYLLOGONIACEAE

PHYLLOGONIUM FULGENS (Sw.) Brid. SURINAM: common, epiphytic on *Clusia* bush, 1 km. west of East Ridge, Tafelberg, *24598 M*. Mexico, Central America, West Indies, South America. A conspicuous moss characterized by the glossy, crowded, keeled leaves in two lateral rows.

HOOKERIACEAE

CALLICOSTELLA ASPERA (Mitt.) Jaeg. SURINAM: Toekoemoetoe Creek, Saramacca River, *24073 M*. Northern South America. The distinctions between this species and *C. scabriseta* (Hook.) Jaeg. are very slight, and it is probable that they are both representative of a single specific concept.

THUIDIACEAE

THUIDIUM ACUMINATUM Mitt. SURINAM: frequent, high bush, northwest Savanna VIII, Tafelberg, *24433 M–1, 24434 M–1*. Jamaica. This species does not seem to have been recorded before from South America.

PLAGIOTHECIACEAE

PILOSIUM CHLOROPHYLLUM C. M. SURINAM: Posoegronoe, Saramacca River, *24033 M–1*. Central America, Panama, West Indies, South America. This species has a rather extensive synonymy as noted by Grout (Bryologist **48**: 68. 1945).

SEMATOPHYLLACEAE

SEMATOPHYLLUM SUBSIMPLEX (Hedw.) Mitt. SURINAM: Posoegronoe, Saramacca River, *24033 M;* frequent, wet rocks, high bush, base north escarpment, Tafelberg, *24339 M–3*. Mexico, Central America, West Indies, South America. A frequent and widely distributed tropical American moss.

TRICHOSTELEUM PAPILLOSUM (Hornsch.) Jaeg. SURINAM: overhanging Tafelberg Creek, Saramacca River Headwaters, *24897 M*. Guiana, Brazil.

Pteridophyta[6]

The present list of Pteridophyta collected by Dr. Bassett Maguire and his associates in British Guiana and Surinam in 1944 may be considered as a supplement to Dr. O. Posthumus' *Ferns of Surinam*,[7] which actually treats not only the Surinam species but also those known from British Guiana and French Guiana as well.

Posthumus records 354 species from the Guianas, of which 190 are known from Surinam. However, it must be remarked that Posthumus held a very broad specific concept and that critical work on his material might show the

[6] By William R. Maxon & C. V. Morton. Published by permission of the Secretary of the Smithsonian Institution.

[7] Published as a supplement to *Flora of Suriname* by A. Pulle, pp. 1–196. 1928.

presence of a number of additional species. The present list adds about 20 species to the known flora, some of them new, and others representing notable extensions of range. Most of the new records are based on plants collected at Tafelberg. The fern flora of this mountain shows some relationship with that of Mount Roraima, especially in the presence of the genus *Syngramma*. It is, however, far less rich in species and is not a center of endemism for Pteridophyta.

The only significant work published on Guiana ferns since Posthumus' work is Mr. A. H. G. Alston's "Pteridophyta collected by the Oxford Expedition to British Guiana, 1929,"[8] which adds a number of species to the known flora.

The present enumeration follows the order of genera given in Christensen's Supplement III of his *Index Filicum*. His nomenclature is followed also, except for the recognition of *Polytaenium, Dicranopteris, Actinostachys,* and *Amphidesmium* as generically distinct from *Antrophyum, Gleichenia, Schizaea,* and *Alsophila* respectively.

HYMENOPHYLLACEAE

Trichomanes anomalum Maxon & Morton, sp. nov. Planta parva, frondibus caespitosis ad 7 cm. longis; rhizoma breve, erecta, hirsuta; stipites breves (usque ad 16 mm. longi) vel subnulli, apicem versus late alati, longe stellato-hirsuti, pilis breviter stipitatis, radiis 3–6, patentibus; lamina oblongo-linearis, usque ad 5.5 cm. longa et 1.7 cm. lata, apice obtusa, basi truncata, non angustata, pinnatipartita, rhachi utroque latere ca. 0.75 mm. alata; segments 14–18-juga, patentia, 7–9 mm. longa, 3.5–4 mm. lata, apice rotundata, pinnato-lobata, lobis utroque latere 5 vel 6, 0.5–1 mm. longis, rotundatis; venae 5- vel 6-jugae, basales furcatae, superiores simplices, in pagina superiore perspicue alatae, alis disjunctis, patentibus, viridibus, deltoideis vel triangularibus, margine et apice hirsutis; lamina tenuiter membranacea, margine perspicue ciliata, pilis stellatis, sessilibus, longe-radiatis, radiis 3–6, in venis utrinque longe stellato-pilosa, pilis breviter stipitatis, longe-radiatis, radiis unicellularibus; involucrum terminale, solitarium, obconicum, breve, ca. 1.5 mm. longum, toto immersum, truncatum, ciliatum, labiis nullis; receptaculum longe exsertum.

TYPE: U. S. National Herbarium, No. 1,879,309. On stream bank, Kaieteur Savannas, British Guiana, May 12, 1944, *Maguire & Fanshawe 23414*.

By the conspicuous accessory wings along the veins of the upper surface the present species can be related only to *T. pilosum* Raddi. These wings are entirely similar to those occurring in several species of *Hymenophyllum,* particularly to those of *H. lobato-alatum*. They are small green outgrowths from the back of the veins and are composed of cells similar to those of the ordinary leaf tissue. They are disposed in a plane perpendicular to the leaf surface. *Trichomanes pilosum* is a much larger plant, coarser in every way, and the leaf segments have many more pairs of veins and lobes. Also, the blade is reduced toward the base, rather than truncate as in the present species.

[8] Kew Bull. 1932: 305–317.

The solitary terminal involucre may prove to be characteristic of the present species also.

TRICHOMANES ARBUSCULA Desv. BRITISH GUIANA: on rocks or fallen logs, Takutu Creek to Puruni River, Mazaruni River, *F2129;* Kaieteur Savannas, *23391;* one mile below Kaieteur Falls, *23420, 23421.* SURINAM: low forest, vicinity of Black Water Camp (5), Coppenam River Headwaters, *24174a.*

TRICHOMANES BOTRYOIDES Kaulf. SURINAM: locally frequent in recess in clay bank in high forest, North Ridge Creek, Tafelberg, *24810.*

TRICHOMANES CELLULOSUM Klotzsch. BRITISH GUIANA: in low bush, Kaieteur Savannas, *23392.* SURINAM: frequent in stream bed in dakama forest, Arrowhead Basin, Tafelberg, *24621.* Not previously reported from Surinam.

TRICHOMANES CRISTATUM Kaulf. BRITISH GUIANA: abundant on fallen logs, wet cliffs, or sometimes on dry rock-shelves, Takutu Creek to Puruni River, Mazaruni River, *F2128;* Tukeit to Kaiatuk Plateau, *23088;* one mile below Kaieteur Falls, *23428, 23429.* SURINAM: Black Water Camp (5), Coppenam River Headwaters, *24174;* Tafelberg, *24293, 24367, 24504, 24770.* The group of species related to *T. crispum* is a complex one. *Trichomanes cristatum* is here recognized in its broadest sense, following Posthumus. A monographic study might show that the collections here listed could be segregated into two or more species.

TRICHOMANES ELEGANS L. C. Rich. BRITISH GUIANA: tufted erect plants 30–45 cm. high, on moist rocks, mature leaves with a metallic blue-green coloration, one mile below Kaieteur Falls, *23422,* depauperate, *23432, 23433;* Takutu Creek to Puruni River, Mazaruni River, *F2170.* Distinguished from the related *T. rigidum* Swartz by its alate rhachis, this being bisulcate and more or less pilose on the ventral surface. The rhachis of *T. rigidum* is terete and glabrate throughout.

TRICHOMANES HOOKERI Presl. BRITISH GUIANA: frequent on wet rocks, Potaro River Gorge, *23532.* SURINAM: between km. 16 and 19, Coppenam River Headwaters, *24168;* Arrowhead Basin, Tafelberg, *24622.* Material of typical *T. Hookeri* from Jamaica and the other islands of the Greater Antilles is rather uniformly large and of distinctive appearance. The smaller plant of Martinique, Guadeloupe, and the Guianas is referred by Alston to *T. cordifolium* (Fée) Alston (based on *Didymoglossum cordifolium* Fée, from Martinique), but it does not seem to us specifically separable.

TRICHOMANES HOSTMANNIANUM Klotzsch. BRITISH GUIANA: common on rocks, Tukeit, *23541.* SURINAM: Black Water Camp (5), Coppenam River Headwaters, *24175;* km. 68, vicinity of Sectie O, *24990.* Distinguished from *T. pinnatum* Hedw., which is habitally similar, by the absence of false cross-veins between the primary veins.

TRICHOMANES HYMENOPHYLLOIDES v. d. Bosch. BRITISH GUIANA: repent on tree trunk, one mile below Kaieteur Falls, *23423.* Apparently included by Posthumus in *T. pyxidiferum* L., which differs in the presence of false veins, among other characters.

TRICHOMANES KRAUSSII Hook. & Grev. SURINAM: frequent on wet rocks and walls, north escarpment, Tafelberg, *24339.* A common and widespread species.

TRICHOMANES PEDICELLATUM Desv. SURINAM: Vicinity of Krappa Camp (2), Saramacca River Headwaters, *24143;* frequent on tree trunks, maka-

pina-tete swamp, Coppenam River Headwaters, *24849*. Related to *T. Tuerckheimii* (of the section *Lacostea*), from which it is easily distinguished by its deeply pinnatifid pinnae.

TRICHOMANES PILOSUM Raddi. BRITISH GUIANA: on tree trunks or fallen logs, Sebai Creek, Kaituma River, *F2425*. Habitally similar to *T. cristatum*, but distinguished by the conspicuous accessory wings on the veins of the upper surface and by its dense pubescence.

TRICHOMANES PINNATUM Hedw. SURINAM: a frequent terrestrial species in high bush or low forest, Black Water Camp (5), Coppenam River Headwaters, *24173*; Arrowhead Basin, Tafelberg, *24448*; lower North Ridge Creek, Tafelberg, *24809a*. Here construed to include *T. pennatum* Kaulf., recognized as distinct by Posthumus and Alston.

TRICHOMANES RIGIDUM Swartz. SURINAM: frequent, in high forest, fronds deep pellucid green, East Ridge Creek Gorge, Tafelberg, *24537*.

TRICHOMANES TRIGONUM Desv. SURINAM: frequent in rocks in stream bed, high mixed forest, Arrowhead Basin, Tafelberg, *24620*. The specimen is not typical, having the pinnae more deeply pinnatifid than usual. Not previously reported from Surinam.

TRICHOMANES TROLLII Bergdolt. BRITISH GUIANA: Takutu Creek to Puruni River, Mazaruni River, *F2114*. SURINAM: locally frequent on clay banks in mixed montane forests, vicinity of Krappa Camp (2), Saramacca River Headwaters, *24137*; lower North Ridge Creek, Tafelberg, *24809*. This is doubtless included by Posthumus in *T. diversifrons* (Bory) Mett., but that species seems sufficiently distinct by the characters originally pointed out by Bergdolt. *Trichomanes Trollii* has been reported in the literature only from Bolivia, but it has been collected previously in British Guiana by Tutin (No. 383, Cuyuni River). A related form, perhaps undescribed, was collected long ago at Panure, Río Vaupes, Colombia, by Spruce (No. 2944). This was distributed as *T. elegans* Rudge, which, from the illustration, was apparently based on a mixture of *T. botryoides* and either *T. Trollii* or *T. diversifrons*. In any case the specific epithet is invalidated by the earlier *T. elegans* L. C. Rich.

TRICHOMANES TUERCKHEIMII Christ. SURINAM: repent epiphyte, vicinity of Krappa Camp (2), Saramacca River Headwaters, *24141*. Related to the widespread *T. Ankersii* Parker, but distinguished by its broad, entire or lightly crenulate pinnae. It was described originally from Loreto, Peru. At the same time Christ reported it from Guatemala, and it has been collected also in Colombia (La Concepción, *Archer 1947*, and Barranca Bermeja, *Haught 1351*). Not previously reported from Surinam.

TRICHOMANES VITTARIA DC. SURINAM: infrequent, km. 18.5, Coppenam River Headwaters, *24839*. A rare and distinctive species known until recently only from the Guianas and northern Brazil. In 1943 it was found also in Amazonian Colombia (Cerro Chiribiquete, Río Macaya, Upper Apaporis Basin, Vaupes, alt. 2100 feet, *Schultes 5653*).

HYMENOPHYLLUM FENDLERIANUM Sturm. SURINAM: frequent epiphyte, in swamps, 1.5 km. south of Savanna I, Tafelberg, *24363*. Easily distinguished from the other species of the Guianas by the glabrous, conspicuously undulate-crispate fronds. Reported from British Guiana but not known previously from Surinam.

HYMENOPHYLLUM HIRSUTUM (L.) Swartz. *H. ciliatum* Swartz. BRITISH

GUIANA: on moist rock, 1 mile below Kaieteur Falls, *23424*. SURINAM: on dripping walls, west of Grace Falls, Tafelberg, *24513;* below south escarpment of Arrowhead Basin, Tafelberg, *24496*.

HYMENOPHYLLUM POLYANTHOS (Swartz) Swartz. SURINAM: on mossy fallen tree trunks, west escarpment, Tafelberg, *24694;* Arrowhead Basin, Tafelberg, *24466;* 2 km. south of East Ridge, Tafelberg, *24579a*.

HYMENOPHYLLUM TRAPEZOIDALE Liebm. SURINAM: common in deep moss on tree trunks, 2 km. south of East Ridge, Tafelberg, *24579*. Known previously only from Mexico and Colombia.

HYMENOPHYLLUM sp. SURINAM: North Ridge, Tafelberg, *24240*. Allied to *H. protrusum* Hook.

CYATHEACEAE

HEMITELIA HIRSUTA (Desv.) Weatherby. *H. Parkeri* Hook. BRITISH GUIANA: infrequent, along trail in dense second growth in windfall opening, Kamuni Creek, Essequibo River, *22857*. Juvenile.

HEMITELIA MACROCARPA Presl. BRITISH GUIANA: tree-fern 2–5 m. high, Kaieteur Savannas, *23387*. SURINAM: 1.5 km. southwest of Savanna II, Tafelberg *24359*. Not known previously from Surinam.

ALSOPHILA MARGINALIS Klotzsch. SURINAM: tree-fern 3 m. high, on slopes overlooking a stream in high forest, East Ridge Gorge, Tafelberg, *24544*. This is a fine specimen of a very rare species of the section *Trichopteris*, described originally from Mount Roraima and until now known otherwise only from Mexico.

ALSOPHILA MICRODONTA Desv. SURINAM: km. 68 and 70, vicinity Sectie O, *23626, 24992*. A common and widespread species.

ALSOPHILA OBLONGA Klotzsch. SURINAM: tree-fern 2.5 m. high, the trunk 5 cm. in diameter, stem exuding copious gelatine, in bamboo thicket in small opening in high forest near escarpment, south of East Ridge, Tafelberg, *24543;* Arrowhead Basin, Tafelberg, *24495a*, sterile juvenile plant. The identification has been confirmed by comparison with a fragment of the type (*Schomburgk 1125*, from British Guiana) at the New York Botanical Garden. Herbarium material currently referred to *A. oblonga* apparently represents several species.

ALSOPHILA PUNGENS (Willd.) Kaulf. BRITISH GUIANA: stem 12 inches long, the leaves 10–15, 5–7 feet long, frequent in dense second growth in windfall opening, Kamuni Creek, Essequibo River, *22854*.

AMPHIDESMIUM ROSTRATUM (Humb. & Bonpl.) J. Smith. BRITISH GUIANA: common on forest floor, the rhizome horizontal, coarse, Kamuni Creek, Groete Creek, Essequibo River, *22821a*.

POLYPODIACEAE

DRYOPTERIS EXTENSA (Blume) Kuntze. BRITISH GUIANA: near roadside, Garraway Stream, Potaro River, *22983*. This is one of the few Old World ferns that has become naturalized in the American tropics. It has been collected in Guadeloupe, St. Lucia, Tobago, Trinidad, and British Guiana. From the native species of the section *Cyclosorus* it is at once distinguished by the bright yellow glands on the veins beneath.

DRYOPTERIS HOSTMANNII (Klotzsch) Maxon & Morton. SURINAM: fre-

quent terrestrial fern in high mixed forest, at base of north escarpment, Tafelberg, *24304a*.

DRYOPTERIS MENISCIOIDES (Willd.) Kuntze var. CONFERTA Morton. BRITISH GUIANA: common on forest floor, Kamuni Creek, Essequibo River, *22821*. A widespread plant in South America, but not often collected. Called *Cyclodium meniscioides* by Posthumus.

DRYOPTERIS OCHROPTEROIDES (Baker) C. Chr. SURINAM: frequent, terrestrial fern in high forest below north escarpment, Tafelberg, *24345;* base of cliff, west of Grace Falls, Tafelberg, *24503*. A specimen from one mile below Kaieteur Falls, British Guiana, *23434*, is probably a juvenile of this species. This rare and distinctive species has a peculiar distribution. It has been known previously upon three collections from Jamaica, one from eastern Panama, and one from Colombia. The last is the basis of *Dryopteris popayanensis* (Hieron.) C. Chr.

DRYOPTERIS PROTENSA (Afzel.) C. Chr. var. FUNESTA (Kunze) C. Chr. BRITISH GUIANA: Kamuni Creek, Essequibo River, *22856, 22871*. SURINAM: vicinity of Krappa Camp (2), Saramacca River Headwaters, *24140;* Augustus Falls, base of north escarpment, Tafelberg, *24773*. This is considered by Alston to be specifically distinct from the African *D. protensa*, perhaps correctly.

DRYOPTERIS SANCTI-GABRIELI (Hook.) Kuntze. BRITISH GUIANA: Potaro River Gorge, *23525*, atypical and probably juvenile. SURINAM: in high mixed forest, lower North Ridge Creek, Tafelberg, *24815;* Arrowhead Basin, Tafelberg, *24468*. A rare species, not previously known from Surinam.

DRYOPTERIS SERRATA (Cav.) C. Chr. SURINAM: at km. 68, Sectie O, *24991*. A widespread common species.

DIDYMOCHLAENA TRUNCATULA (Swartz) J. Smith. BRITISH GUIANA: terrestrial fern forming large clumps with 8–12 fronds, Takutu Creek to Puruni River, Mazaruni River, *F2059*.

POLYBOTRYA CAUDATA Kunze. BRITISH GUIANA: climbing fern, leaves bipinnate, 4–5 feet long, dimorphic, fertile leaves 2, 2–3 feet long, in dense thickets in heavy mora forest, Kamuni Creek, Essequibo River, *22855*.

TECTARIA PLANTAGINEA (Jacq.) Maxon. SURINAM: frequent along streams on rocks, vicinity of Kwatta Camp (3), Coppenam River Headwaters, *24148;* km. 24.5, Coppenam River Headwaters, *24829*.

TECTARIA TRIFOLIATA (L.) Cav. SURINAM: locally frequent in high mixed forest, at base of north escarpment, Augustus Falls, Tafelberg, *24768*.

BOLBITIS ALIENA (Swartz) Alston. SURINAM: mossy boulders in high mixed forest, Augustus Falls, Tafelberg, *24767*.

Bolbitis Maguirei Maxon & Morton, sp. nov. Rhizoma repens, lignosum, brunneum, ca. 8 mm. diam., dense paleaceum, paleis anguste ovatis, attenuatis, usque ad 3 mm. longis et 0.8 mm. latis, imbricatis, brunneis, sublaceratis. Folia disticha, sterile fertili paulum longius. Folium sterile 100 cm. longum; stipes 40 cm. longus, 4–5 mm. diam., olivaceus, glaber, obscure paleaceus, paleis anguste ovatis, attenuatis, ca. 2 mm. longis, eroso-laceratis, clathratis, tenuissimis, adpressis, plerisque mox delapsis; lamina late oblonga, abrupte acuminata, 60 cm. longa, ca. 35 cm. lata, pinnata, rhachi sicut stipite hinc inde tenere paleacea; pinnae ca. 14- jugae, arcuatim adscendentes, lineares, acuminato-caudatae, 5- vel 6-jugae, inferiores petiolulatae (4–7 mm.), basi inaequali late cuneatae, subaequales, 24–28 cm. longae, 3–4.3

cm. latae, undulato-crenatae, superiores sensim minores, sessiles, leviter crenatae, pinna apicalis multo major, undulato-crenata, costis elevatis, parce paleaceis; costulae majores ca. 28-jugae, patentes, tenues, utrinque prominulae, marginem fere attingentes; maculae costales anguste subtriangulares, 7–9 mm. longae, 2.5–3 mm. latae; maculae costulares 2–4, elongatae, exappendiculatae; maculae alterae paucae, ambitu modoque variae, saepe appendiculatae, radiis simplicibus, exteriores apertae, venulis liberis hydathodis marginalibus vel submarginalibus gracillimis desinentibus. Folium fertile 85 cm. longum, stipite (45 cm.) et rhachi sicut folio sterili hinc inde tenere paleaceis; lamina anguste oblonga, apice acuta, 40 cm. longa, 15 cm. lata, pinnata; pinnae 15-jugae, remotae, lineares, apice obtusae, basi inaequali late cuneatae, petiolulatae (infimae 6–7 mm.), maximae 8.5 cm. longae, 12 mm. latae, marginibus subintegris; sporangia fusco-brunnea, crebra, fere ad marginem revolutam diffusa, costa non occulta; sporae subsphaeroideae, 44–56 μ diam., perspicue tuberculatae.

TYPE: U. S. National Herbarium, Nos. 1,879,451–2. Dense forest near Augustus Falls, Tafelberg, Surinam, September 15, 1944, *Maguire 24744*.

From Christensen's Revision[9] this species is most closely allied to *B. serratifolia* (Mertens) Schott, a rather widely distributed species which may be distinguished at once from the present by its uncinate-serrate rather than crenate-lobate pinnae. It is related also to *B. crenata* (Presl) C. Chr., which differs in its appendiculate maculae.

Bolbitis scopulina Maxon & Morton, sp. nov. Rhizoma repens, lignosum, brunneum, ca. 6 mm. diam., dense adpresso-paleaceum, paleis elongato-triangularibus, apice attenuatis, 1.5–3 mm. longis, 0.3–0.8 mm. latis, imbricatis, brunneis, opacis, fibrosis, hinc inde lacerato-dentatis. Folia disticha, pauca, inter se ca. 1 cm. remota, adscendentia, sterile quam fertili paulum longius. Folium sterile 60 cm. longum; stipes 30 cm. longus, 1.5–2 mm. diam., olivaceus, glaber, basi squamosus; lamina ambitu orbiculari-ovata, 30 cm. longa, ca. 25 cm. lata, pinnata, rhachi compressa, 3 cm. longa; pinnae 2-jugae cum impari, lanceolatae vel lanceolato-ellipticae, longe acuminatae, membranaceae, glabrae, basales oppositae, subpetiolulatae, 17 cm. longae, 4.5 cm. latae, basi inaequaliter cuneatae (postice dimidiatae), pinnae alterae alternae, semiadnatae, decurrentes, terminalis multo maxima, 27 cm. longa, 6.5 cm. lata, marginibus basin versus undulatis, superne remote et minute serratis, apicem versus leviter crenato-serratis; costulae majores ca. 15-jugae, angulo lato fere ad marginem egredientes, tenues; maculae costales humiles, lineares, majores 10–15 mm. longae et 2–3 mm. latae; maculae costulares (3 vel 4) ambitu costalibus simillimae, saepe appendiculatae, alterae varie dispositae, crassae, pleraeque hexagonae, majores appendiculatae, radiis simplicibus vel furcatis, minores et praesertim marginales exappendiculatae. Folium fertile 54 cm. longum; stipes gracilis, 43 cm. longus; lamina ambitu ovata, 11 cm. longa, 7 cm. lata, basi pinnata, sursum pinnatisecta, segmentis 2-jugis cum impari, lateralibus oppositis et aequalibus, ellipticis, 4–4.5 cm. longis, ca. 8 mm. latis, basalibus petiolulatis (2 mm.), superioribus semiadnatis, decurrentibus, segmento apicali anguste trilobato, longe decurrente, 8.5 cm. longo, marginibus integris; sporangia fere ad marginem tenuiter diffusa; sporae subglobosae, 50–55 μ diam., alatae.

[9] "On the American species of *Leptochilus*, Sect. *Bolbitis*," Bot. Tidssk. 26: 283–297. 1904.

TYPE: New York Botanical Garden. Mixed montane forest, on wet walls of lower North Ridge Creek, Tafelberg, Surinam, September 19, 1944, *Maguire 24814*. The present species belongs to the section *Anapausia*, but is evidently not closely allied to the other species of the section.

OLEANDRA ARTICULATA (Swartz) Presl. BRITISH GUIANA: dry rock ledge, one mile below Kaieteur Falls, *23431;* occasional in high mixed forest on trail from Kaiatuk to Tukeit, *23474*. SURINAM: frequent, climbing on damp shaded walls of gorge above Lisa Falls, Tafelberg, *24366*. Referred by Posthumus to *O. nodosa* (Willd.) Presl, which, as long ago pointed out,[10] must be regarded as a synonym.

OLEANDRA PILOSA Hook. BRITISH GUIANA: stem woody, procumbent, leaves crowded at apex, rare, on dry rock ledge, Kaieteur Savannas, *23142*.

NEPHROLEPIS PENDULA (Raddi) J. Smith. BRITISH GUIANA: tufted, short ascending rhizome, with 10–20 fronds, locally frequent in rock fissures in sandy soil, Kaieteur Savannas, *23137, 23143*.

ITHYCAULON INAEQUALE (Kunze) Copel. *Saccoloma inaequale* Mett. SURINAM: frequent at Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, *24114*.

LINDSAEA CORIIFOLIA Lindm. BRITISH GUIANA: on white sand, Kaieteur Savannas, *23394*. Identified from description and from the excellent illustrations of Lindman. The type was said, perhaps incorrectly, to have come from Caracas.

LINDSAEA CRENATA Klotzsch. BRITISH GUIANA: moist rock ledge, one mile below Kaieteur Falls, *23427*. SURINAM: frequent in damp soil in high bush, at base of north escarpment, Tafelberg, *24325*. As the specimens are sterile, the identification is somewhat uncertain. Not known previously from Surinam.

LINDSAEA DUBIA Spreng. SURINAM: terrestrial, frequent, vicinity of Krappa Camp (2), Saramacca River Headwaters, *24136;* below north escarpment, Tafelberg, *24345a;* along East Ridge Creek, Tafelberg, *24531*.

LINDSAEA FALCATA Dryander. SURINAM: frequent on forest floor, vicinity Black Water Camp (5), Coppenam River Headwaters, *24181;* trail from Savanna I to North Ridge, Tafelberg, *24244;* mixed high forest, slopes of Hill 2, between North Ridge and Augustus Creeks, Tafelberg, *24736*.

LINDSAEA LANCEA (L.) Bedd. BRITISH GUIANA: infrequent in mixed forest, Kamuni Creek, Essequibo River, *22917*.

LINDSAEA PARKERI Hook. BRITISH GUIANA: Kaieteur Savannas, *23413;* rare on moist rocks, Amatuk Portage, *23543*. SURINAM: frequent on mossy banks, lower Augustus Creek, Tafelberg, *24731*. A rare species not known previously from Surinam.

LINDSAEA PENDULA Klotzsch. BRITISH GUIANA: locally frequent in sedge bog, Kaieteur Savannas, *23160*.

LINDSAEA RENIFORMIS Dryander. SURINAM: frequent along stream borders on east side of North Ridge, Tafelberg, *24243;* frequent in boggy area along stream, 5 km. northwest of Savanna I, Tafelberg, *24817*. Posthumus regards this species as synonymous with *L. sagittata* (Aubl.) Dryander.

LINDSAEA STRICTA (Swartz) Dryander. BRITISH GUIANA: locally frequent in sedge bog, Kaieteur Savannas, *23159*. SURINAM: in wet places in thickets, Savanna IV, Tafelberg, *24377*.

[10] Contr. U. S. Nat. Herb. 17: 396. 1914.

LINDSAEA sp. BRITISH GUIANA: rare, Amatuk Portage, Potaro River Gorge, *23548*. The plants, which are nearly sterile, run to *L. falciformis* in Posthumus' key, but the venation does not agree very well with Hooker's illustration. That species is apparently known only from the original collection from Mount Roraima.

DIPLAZIUM LECHLERI (Mett.) Moore. SURINAM: terrestrial, rootstock horizontal-ascending, gelatinous, in high mixed forest at base of north escarpment, Tafelberg, *24303*. A distinctive species, not previously known from Surinam, but reported from British Guiana. It ranges from Costa Rica to Peru, but is everywhere rare.

ASPLENIUM ANGUSTUM Swartz. SURINAM: infrequent epiphyte, makapina-tete swamp, km. 13, Coppenam River Headwaters, *24852*.

ASPLENIUM AURITUM var. OBTUSUM (Kunze) Mett. SURINAM: frequent epiphyte in high forest, Arrowhead Basin, Tafelberg, *24479;* Augustus Falls, Tafelberg, *24753*. Listed by Posthumus as *A. sulcatum* Lam., which may be the proper specific epithet.

ASPLENIUM DIMIDIATUM Swartz. SURINAM: frequent terrestrial fern, high forest, in dense shade, below south escarpment of Arrowhead Basin, Tafelberg, *24506*. An extreme form referred here with misgiving. It differs from typical material of *A. dimidiatum*, of which an excellent series is at hand from the Greater Antilles, in its stout, densely scaly vascular parts, its more leathery texture, and in having the pinnae deeply excavate below, a condition not commonly seen in typical material, which has the pinnae merely dimidiate.

ASPLENIUM INTEGERRIMUM Spreng. SURINAM: epiphyte, Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, *24113*. So identified in accordance with Domin's streatment[11] of this variable group. Listed by Posthumus as *A. Kapplerianum*.

ASPLENIUM PEDICULARIIFOLIUM St. Hil. SURINAM: frequent on mossy rocks in dense shade below south escarpment of Arrowhead Basin, *24505a*. The specimen agrees very well with the original description and with a Brazilian specimen (locality not stated) in the New York Botanical Garden collected by Glaziou (No. 15740). Posthumus recorded this species from a single locality in Surinam (Brownsberg). It is a characteristic species without obvious relatives.

ASPLENIUM PERKINSII Jenm. SURINAM: on mossy rocks in dense shade, below south escarpment of Arrowhead Basin, Tafelberg, *24505*; Arrowhead Basin, Tafelberg, *24600a*. The first specimen cited is in substantial agreement with the rather poor type specimen at the New York Botanical Garden; the second is slightly more divided. The relationship is with *A. rutaceum* Mett. and *A. conquisitum* Underw. & Maxon. The status of these species should be reviewed in the light of the abundant material now avaiable.

ASPLENIUM SALICIFOLIUM L. SURINAM: frequent terrestrial fern among rocks and boulders, base of north escarpment, Tafelberg, *24304;* below south escarpment of Arrowhead Basin, Tafelberg, *24517*.

ASPLENIUM SERRA Langsd. & Fisch. SURINAM: infrequent, terrestrial fern in damp high bush, base of north escarpment, Tafelberg, *24331*.

ASPLENIUM SERRATUM L. SURINAM: frequent on moist rocks in montane forest, north slopes of Tafelberg, *25063*.

[11] Pterid. Dominica 167. 1929.

BLECHNUM GRACILE Kaulf. SURINAM: frequent on moist rocks, north escarpment, Tafelberg, *24291;* Arrowhead Basin, Tafelberg, *24467, 24499.* The identification follows Posthumus. The group of *B. occidentale* L. is a complex one. Typical *B. occidentale* has blades with a regularly tapering apex and numerous pinnae, whereas *B. gracile* is essentially imparipinnate, the apex being elongate and subentire. Not previously reported from Surinam.

BLECHNUM INDICUM Burm. *B. serrulatum* L. C. Rich. SURINAM: savanna, vicinity of Sectie O, *25016.*

SYNGRAMMA sp. Two collections of this genus, one from Kaieteur Falls, *23430,* and one from Tafelberg, *24500,* will be discussed by the junior author in a separate paper in which the American species of *Syngramma* and *Pterozonium* will be treated. The presence of *Syngramma* on Tafelberg is of interest, since it shows clearly the relationship of the fern flora to that of Mount Roraima.

PITYROGRAMMA CALOMELANOS (L.) Link. BRITISH GUIANA: Kamuni Creek, Essequibo River, *22844.* Surinam: vicinity of Tawa Creek, Saramacca River, *23748;* base of north escarpment, Tafelberg, *24294;* vicinity of Sectie O, *25026.*

DORYOPTERIS SAGITTIFOLIA (Raddi) J. Smith. SURINAM: infrequent, on rocks in high mixed forest, Augustus Falls, Tafelberg, *24759.* An unusually large form.

ADIANTUM CAYENNENSE Willd. BRITISH GUIANA: frequent, terrestrial in dense second growth in windfall opening in heavy mora forest, Kamuni Creek, Essequibo River, *22858.* Considered as synonymous with *A. tetraphyllum* H.B.K. by Posthumus.

ADIANTUM DOLOSUM Kunze. BRITISH GUIANA: frequent, terrestrial in dense second-growth thickets, Kamuni Creek, Essequibo River, *22859.*

ADIANTUM LATIFOLIUM Lam. BRITISH GUIANA: frequent, along trail and in clearings, Kamuni Creek, Essequibo River, *22845;* Takutu Creek to Puruni River, Mazaruni River, *F2141.* SURINAM: along railroad, km. 70, *23065;* vicinity of Tawa Creek, Saramacca River, *23747.* No. 22845 has unusually small segments, but apparently must be referred here.

ADIANTUM PETIOLATUM Desv. SURINAM: frequent on river banks, Tafelberg Creek, Saramacca River Headwaters, *24077.*

ADIANTUM PULVERULENTUM L. SURINAM: frequent in deep shade of heavy bush on rocky slopes and river banks, Jacob kondre, Saramacca River Headwaters, *23827, 23828.*

ADIANTUM TERMINATUM Kunze. SURINAM: frequent in damp soil in high bush or mixed forest, base of north escarpment, Tafelberg, *24324, 24747.*

PTERIS ALTISSIMA Poir. *P. Kunzeana* Agardh. SURINAM: stem short, erect, in dense, damp high forest, vicinity of Augustus Falls, Tafelberg, *24743.*

PTERIS PUNGENS Willd. BRITISH GUIANA: Takutu Creek to Puruni River, Mazaruni River, *F2060, juvenile.* SURINAM: high bush, base of north escarpment, Tafelberg, *24342.*

VITTARIA FILIFOLIA Fée. SURINAM: on steep slopes in high forest, East Ridge Creek Gorge, Tafelberg, *24535.* Not previously recorded from Surinam.

VITTARIA LINEATA (L.) J. E. Smith. BRITISH GUIANA: Kamuni Creek, Groete Creek, Essequibo River, *22872;* Mazaruni Station, *F2188.* SURINAM: pendent epiphyte, Charlesburg Rift, 3 km. north of Paramaribo, *22797;* maka-pina-tete swamp, Coppenam River Headwaters, *24851.*

VITTARIA REMOTA Fée. SURINAM: On rocks between Augustus and North Ridge Creeks, Tafelberg, *24188;* Arrowhead Basin, Tafelberg, *24463.*

HECISTOPTERIS PUMILA (Spreng.) J. Smith. SURINAM: common on moist cliff on base of north escarpment, Tafelberg, *24187.*

HECISTOPTERIS PUMILA var. **obtusa** Maxon & Morton, var. nov. A var. typica lobis foliorum obtusis vel rotundatis nec acuminatis differt.

TYPE: New York Botanical Garden. Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, Surinam, July 11, 1944, *Maquire 24101.* According to the notes on the label the plant is infrequent, growing mosslike on trees or fallen logs. A specimen in the National Herbarium collected at Pará by Spruce in 1849 may be the same. Christ[12] described three subspecies of *H. pumila* from Brazil, but all are invalid, being published as binomials in contravention of the International Rules.

POLYTAENIUM BRASILIANUM (Desv.) Benedict. SURINAM: Arrowhead Basin, Tafelberg, *24600.* The genus *Polytaenium* is included in *Antrophyum* by Posthumus.

POLYTAENIUM CAYENNENSE (Desv.) Benedict. BRITISH GUIANA: epiphyte growing on a rope. Takutu Creek to Puruni River, Mazaruni River, *F2155.*

COCHLIDIUM FURCATUM (Hook. & Grev.) C. Chr. BRITISH GUIANA: frequent, epiphytic or on wet rocks, Potaro River Gorge, *23484, 23534.*

POLYPODIUM AUREUM L. BRITISH GUIANA: sandhills, Demerara River, *F1199.*

POLYPODIUM CACERESII Sodiro. BRITISH GUIANA: mossy rocks in high mixed forest on trail from Kaiatuk to Tukeit, *23478.* This species, which is a segregate of the widespread and variable *P. fraxinifolium* Jacq., has been previously known only from the Andes from Colombia to Bolivia. Mr. Weatherby has taken up for the species the name *P. articulatum* Desv., but that is a homonym of the earlier *P. articulatum* Juss. However, an earlier name among the many putative synonyms of *P. fraxinifolium* may be available.

POLYPODIUM CILIATUM Willd. SURINAM: common epiphyte, White Rock Rapids, Saramacca River, *24003;* savanna, Zanderij I, *25048.*

POLYPODIUM DUALE Maxon. BRITISH GUIANA: Amatuk Portage, Potaro River Gorge, *23029;* trail from Kaiatuk to Tukeit, *23480.* SURINAM: north escarpment, between Augustus and North Ridge Creeks, Tafelberg, *24186;* 2 km. south of East Ridge, Tafelberg, *24580;* Arrowhead Basin, Tafelberg, *24464.*

POLYPODIUM FLAGELLARE Christ. SURINAM: infrequent epiphyte in high forest, at base of south escarpment, Arrowhead Basin, Tafelberg, *24478.* The specimen agrees excellently with a series from Panama. A photograph and fragment show that the type (from Surubris, near San Mateo, Costa Rica, *Biolley 2671*) has somewhat narrower pinnae, Not previously reported from Surinam.

POLYPODIUM LYCOPODIOIDES L. var. SALICIFOLIUM (Willd.) Bonap. BRITISH GUIANA: frequent epiphyte, Kamuni Creek, Groete Creek, Essequibo

[12] Hedwigia 44: 366. 1905.

River, *22820;* Mazaruni Station, *F2190.* This is the plant called *P. surinamense* Jacq. by Posthumus, but that should probably be kept as a dubious species. Lindman[13] identified it with a species of Brazil, Uruguay, Paraguay, and Argentina, distinguished from the present plant by its paleaceous frond and other characters. This southern species, which is not known to occur in the Guianas, should be called *P. squamulosum* Kaulf., the name in common use. Jacquin's plate and description call for a plant with serrulate fronds, a character not in accord with either *P. lycopodioides* or *P. squamulosum.* From typical West Indian *P. lycopodioides* the variety *salicifolium* is distinguished primarily by its more prominent venation.

POLYPODIUM MOLLISSIMUM Fée. SURINAM: base of north and south escarpments, Tafelberg, *24498, 24752.* Not previously reported from Surinam, but specimens may have been confused with the related *P. cultratum* Willd.

POLYPODIUM NANUM Fée. SURINAM: infrequent on moss-covered rocks in high mixed forest at base of north escarpment, Augustus Falls, Tafelberg, *24771.* A widespread but uncommon South American species, not previously reported from Surinam.

POLYPODIUM PANORENSE C. Chr. BRITISH GUIANA: on rocks in mixed forest, trail from Tukeit to Kaieteur Plateau, Potaro River Gorge, *23084.* Identified from description. The type was collected by Spruce (No. 2324) at Panuré, on Río Vaupes, Colombia. It was collected also by Mr. A. Roman at Taracuá, on Río Vaupes.

POLYPODIUM PERCUSSUM Cav. SURINAM: locally common epiphyte, White Rock Rapids, Saramacca River, *24006;* Augustus Falls, Tafelberg, *24755;* Savanna I, Tafelberg, *24400.*

POLYPODIUM PERSICARIIFOLIUM Schrad. SURINAM: frequent epiphyte, White Rock Rapids, Saramacca River, *24004.*

POLYPODIUM PHYLLITIDIS L. SURINAM: frequent terrestrial or epiphytic fern, Saramacca River banks above Kwatta hede, *23937;* Gran dam Rapids, Saramacca River, *24012;* Arrowhead Basin, Tafelberg, *24495;* savanna, Zanderij I, *25045.*

POLYPODIUM PLUMULA Humb. & Bonpl. SURINAM: epiphytic or terrestrial, White Rock Rapids, Saramacca River, *24005;* base of north escarpment, Tafelberg, *24754;* Grasi Falls, Saramacca River, *24945.* As currently interpreted this is a widespread and variable species (doubtless an aggregate), listed by Posthumus as *P. hygrometricum* Splitg.

POLYPODIUM POLYPODIOIDES (L.) Watt. var. BURCHELLII (Baker) Weatherby. SURINAM: Jacob kondre, Saramacca River, *23891.* Infrequent in the Guianas.

POLYPODIUM REPENS Aubl. SURINAM: frequent in dense shade of high forest below south escarpment of Arrowhead Basin, Tafelberg, *24507.*

POLYPODIUM TAENIFOLIUM Jenm. SURINAM: epiphyte, southeast of Savanna VIII, Tafelberg, *24567, 24633.* Identified with doubt. This species was described originally from Jamaica, where it is rare, and is known also from Hispaniola. It is abundant in Puerto Rico, the Lesser Antilles, and Trinidad, but has not previously been reported from the Guianas.

POLYPODIUM TAXIFOLIUM L. SURINAM: frequent epiphyte, 1 km. east of

[13] Ark. Bot. 1: 247. 1903.

Savanna VIII, Tafelberg, *24568*. A notable extension of range, this species having previously been known from Hispaniola, Puerto Rico, and the Lesser Antilles. It has been erroneously reported from the Andes.

POLYPODIUM TECTUM Kaulf. SURINAM: locally common epiphyte, White Rock Rapids, Saramacca River, *24002*.

POLYPODIUM TRISERIALE Swartz. *P. brasiliense* Poir. BRITISH GUIANA: sandy soil, Kaieteur Savannas, *23138;* Potaro River Gorge, *23527*, depauperate.

POLYPODIUM sp. SURINAM: frequent epiphyte along streams, east side of North Ridge, Tafelberg, *24239*. We have been unable to identify this with any described species.

ESCHATOGRAMME DESVAUXII (Klotzsch) C. Chr. BRITISH GUIANA: infrequent epiphyte, Kamuni Creek, Groete Creek, Essequibo River, *22849*. SURINAM: maka-pina-tete swamp, Coppenam River Headwaters, *24850*. Included in *E. furcata* (L.) C. Chr. by Posthumus.

ELAPHOGLOSSUM GLABELLUM J. Smith. BRITISH GUIANA: one mile below Kaieteur Falls, *23439*. SURINAM: White Rock Rapids, Saramacca River, *24001*.

ELAPHOGLOSSUM PLUMOSUM (Fée) Moore. SURINAM: frequent epiphyte on tree trunks in low bush, near north escarpment, Tafelberg, *24185*. Identified by the description and plate of Fée.

ELAPHOGLOSSUM RIGIDUM (Aubl.) Urban. *Acrostichum flaccidum* Fée. SURINAM: frequent on damp rocks at base of north escarpment, Tafelberg, *24332*.

ELAPHOGLOSSUM SCHOMBURGKII (Fée) Moore. SURINAM: terrestrial, leaves glossy, frequent in high, moist, boulder-strewn, somewhat open forest below south escarpment of Arrowhead Basin, Tafelberg, *24516*. This species is little known. The identification needs verification by comparison of the specimen with authentic material.

ELAPHOGLOSSUM SPATHULATUM (Bory) Moore. SURINAM: frequent on moss-covered rocks in high forest, Grace Falls, Tafelberg, *24511*.

PARKERIACEAE

CERATOPTERIS PTERIDOIDES (Hook.) Hieron. SURINAM: frequent in marshes along jungle border, Charlesburg Rift, 3 km. north of Paramaribo, *22719*. Included erroneously in the Old World species *C. thalictroides* (L.) Brongn. by Posthumus, who apparently overlooked Dr. Benedict's work on this genus.

GLEICHENIACEAE

DICRANOPTERIS REMOTA (Kaulf.) Maxon. BRITISH GUIANA: erect, spreading fern in exposed lateritic soil, Bartica-Potaro, *F1096;* climber on rock faces and banks along road, Garraway Stream, Potaro River, *22984*. Apparently included by Posthumus in *Gleichenia furcata* (L.) Spreng.

SCHIZAEACEAE

ACTINOSTACHYS PENICILLATA (Humb. & Bonpl.) Maxon. *Schizaea subtrijuga* Mart. BRITISH GUIANA: dry, sandy, open places, one mile below Kaieteur Falls, *23441*.

ACTINOSTACHYS PENNULA (Swartz) Hook. BRITISH GUIANA: locally

frequent in shallow sand or on open dry rocks, Potaro River Gorge, *23518*. SURINAM: Savanna IV, Tafelberg, *24376*, *24394a*; south savannas, vicinity Arawak village of Mata, Zanderij, *24976*.

SCHIZAEA ELEGANS (Vahl) Swartz var. FLABELLUM (Mart.) Prantl. BRITISH GUIANA: rare or infrequent, terrestrial on steep slopes in high mixed forest, Kaieteur Savannas, *23189*. SURINAM: East Ridge Creek Gorge, Tafelberg, *24534*; Arrowhead Basin, Tafelberg, *24613*; dense high bush north of Savanna II, Tafelberg, *24280*, *25070*.

SCHIZAEA INCURVATA Schkuhr. BRITISH GUIANA: Kaieteur Savannas, *23251*. Surinam: grass savanna, Zanderij II, *23668*; Arawak village, Zanderij, *24975*.

LYGODIUM VOLUBILE Swartz. SURINAM: frequent, railroad near km. 70, Sectie O, *23615*; base of north escarpment, Tafelberg, *24295*. A collective species, here regarded in the inclusive sense of Posthumus.

MARATTIACEAE

DANAEA SIMPLICIFOLIA Rudge. SURINAM: infrequent on wet walls of cataract, lower North Ridge Creek, Tafelberg, *24812*. The leaves are relatively a good deal narrower than those of most of the specimens in the National Herbarium.

OPHIOGLOSSACEAE

OPHIOGLOSSUM ELLIPTICUM Hook. & Grev. SURINAM: Locally frequent in sand pocket, Gran dam, Saramacca River, *24926*. Identified by Dr. Robert T. Clausen.

LYCOPODIACEAE

LYCOPODIUM MERIDIONALE Underw. & Lloyd. BRITISH GUIANA: frequent in sedge bog, Kaieteur Savannas, *23111*. SURINAM: frequent, damp sand, Zanderij II, *23690*; frequent, savanna, Zanderij I, vicinity Arawak village Mata, *24981*. Broadly distributed in the American tropics. (Identified by Bassett Maguire.)

LYCOPODIUM CERNUUM L. BRITISH GUIANA: banks, Garraway Stream, Potaro River, *22969*. SURINAM: frequent, railway embankment and ditch bank, km. 70, Sectie O, *23627*; km. 68, *25071*. Broadly distributed in tropical America, extending northward to Florida and Mississippi. (Determined by Bassett Maguire.)

ISOËTACEAE

ISOËTES OVATA Pfeiffer. BRITISH GUIANA: common, buried in sand to 10 cm. deep in river tidal flats, vicinity of Mazaruni Forest Station, *23569*; moist sand between rocks, Takutu Creek to Puruni River, Mazaruni River, *F2093*. Known only from the Mazaruni River. (Identified by Bassett Maguire.)

SELAGINELLACEAE[14]

SELAGINELLA PEDATA Klotzsch. SURINAM: common in clearings, openings in deep wallaba forest, vicinity Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, *24104*. British Guiana, Brazil.

SELAGINELLA EPIRRHIZOS Spring. BRITISH GUIANA: common in moist places, thickets, high mixed forest, Kamuni Creek, Groete Creek, Essequibo

[14] By A. H. G. Alston.

River, *22847;* creeping perennial, adventitious roots, Kamuni Creek, Groete Creek, Essequibo River, *F1821* (determined by Bassett Maguire); Takutu Creek to Puruni River, Mazaruni River, *F2033;* abundant on damp lateritic soil by roadside, *F1189* (determined by Bassett Maguire). British and French Guiana, Brazil.

SELAGINELLA FLAGELLATA Spring. BRITISH GUIANA: common, rock surfaces along small streams, low forest, Kaieteur Plateau, *23416.* SURINAM: infrequent, wet mossy rocks and walls, base of north escarpment, Tafelberg, *24336;* abundant on dripping walls, base of north escarpment, Tafelberg, *24337;* frequent, wet mossy cliff base, Augustus Falls, Tafelberg, *24772;* frequent, moist rocks, east-facing slopes above escarpment, 300 m. south of East Ridge, Tafelberg, *24553.* British and French Guiana, Brazil, Trinidad, Venezuela, Colombia and Central America.

SELAGINELLA REVOLUTA Bak. BRITISH GUIANA: on rock face and at base of rock, Garraway Stream, Potaro River, *22971.* French and British Guiana, Northern Brazil, Venezuela, Colombia, Peru.

SELAGINELLA PRODUCTA Bak. BRITISH GUIANA: occasional, moist rocks, mixed forest, trail from Tukeit to Kaieteur Plateau, *23089;* marsh forest, Sebai Creek, Kaituma River, *F2417.* SURINAM: frequent, moist, soil, on rocks, opening in high bush, base north escarpment, Tafelberg, *24316.* New for Surinam.

SELAGINELLA DENDRICOLA Jenm. SURINAM: infrequent, moist rocks, high forest, base of south escarpment, Arrowhead Basin, Tafelberg, *24497.* New for Surinam.

SELAGINELLA PARKERI (Hook. & Grev.) Spring. BRITISH GUIANA: in riparian forest, Takutu Creek to Puruni River, Mazaruni River, *F2121.* SURINAM: frequent, wet walls cataract, lower North Ridge Creek, Tafelberg, *24813;* frequent, high mixed forest, below cliffs of west escarpment, Tafelberg, *24696;* frequent, montane forest, vicinity Krappa Camp (2), Saramacca River Headwaters, *24142.* Not in the Selaginellaceae of Surinam.[15]

SELAGINELLA MAZARUNIENSIS Jenm. BRITISH GUIANA: 40–50 cm., moist rocks, one mile below Kaieteur Falls, Potaro River Gorge, *23425;* occasional to frequent, repent on rocks, Amatuk Portage, *23024.*

SELAGINELLA POTAROENSIS Jenm. BRITISH GUIANA: occasional, repent on moist rocks, under dripping water, mixed forest, trail from Tukeit to Kaieteur Plateau, *23083.*

SELAGINELLA VALDEPILOSA Bak. BRITISH GUIANA: frequent, rock surfaces along streams, low forest, Kaieteur Plateau, *23415.*

SELAGINELLA TUBERCULATA Spruce. SURINAM: wet rocks, high bush, base of north escarpment, Tafelberg, *24339a.* New for Surinam.

GNETACEAE

GNETUM NODIFLORUM Brongn. SURINAM: infrequent, high-climbing liana, ♂, overhanging river, mixed primary forest, vicinity Jacob kondre, Saramacca River, *23861;* unicate, ♂, only specimen seen, apparently parasitic in the top of tall trees, mixed forest, hill 1.5 km. northeast of Savanna III, Tafelberg, *24716.* Forest areas, more conspicuous along rivers, British Guiana to Pará, Brazil.

[15] *Flora of Suriname,* vol. 1, part 1. 1938.

GNETUM PANICULATUM Spruce. BRITISH GUIANA: rope from tree crown, leaves stiff and brittle, ♂, Barabara Creek, 14 mi. Bartica-Potaro Road, *F823;* 12 cm. diameter, soft brown, finely scaly rope with sticky whitish latex, ♂, Black Creek, Groete Creek, Essequibo River, *F1789.* In the above specimens, the panicles are paired in leaf axils and are much shorter than in *G. paniculatum.* They might well represent a distinct species.

TYPHACEAE

TYPHA DOMINGENSIS Pers. BRITISH GUIANA: perennial herb, pegass swamp, Mabaruma, Aruka River, N. W. D., *F2392.* SURINAM: common, marshes along Saramacca River, vicinity Carl Francois, *23597.* Generally distributed in the American tropics and southern United States.

ALISMACEAE[16]

SAGITTARIA LANCIFOLIA L.[17] BRITISH GUIANA: marsh herb to 2 m. high, vicinity Mazaruni Forest Station, sandy foreshore, river tidal flats, *23569.* Known from the southern United States, West Indian Islands, Central America and tropical South America.

BUTOMACEAE

HYDROCLEIS NYMPHOIDES (Willd.) Buchenau. SURINAM: flowers buff-colored, floating in water to 2 m. deep, locally common, canal 60 km. from Paramaribo on the Carl Francois road, *23590.* Widespread in tropical South America.

GRAMINEAE[18]

ERAGROSTIS CILIARIS (L.) Link. SURINAM: frequent, sand banks along railroad bed, Kwakoegron, *23776.* Common weedy grass, occurring throughout the warmer regions of the world.

ERAGROSTIS GLOMERATA (Walt.) L. H. Dewey. BRITISH GUIANA: open savanna, Rupununi District, *Fraser 351.* West Indies; Venezuela to Bolivia and Argentina. This is the first record for British Guiana of a common rather wide-spread species.

ERAGROSTIS MAYPURENSIS (H.B.K.) Steud. BRITISH GUIANA: white sand, Waratuk Falls, Potaro River Gorge, *23049.* Southern Mexico to Brazil and Bolivia.

STEIRACHNE DIANDRA Ekman. BRITISH GUIANA: slender tufted grass of moist or dry sandy places, Rupununi, *Fraser 358.* This is the first record for British Guiana. Venezuela, British Guiana, and Northeastern Brazil.

STREPTOGYNE CRINITA Beauv. SURINAM: frequent, conspicuous with elongate blades and mature fruits hanging by the elongate entangled stigmas, forest floor, trail to Coppenam River, rear of village, Pakka Pakka, *23975.* Wet forests, Mexico, Guatemala, Panamá, Trinidad, Surinam, and northern Brazil.

ORTHOCLADA LAXA (L. Rich.) Beauv. BRITISH GUIANA: roadside grass on lateritic gravelly soil, Mabaruma, Aruka River, *F2355.* A woodland grass with long, fine, readily disarticulating panicle branches and relatively broad petiolate blades. Mexico to Brazil and Peru.

---

[16] By F. P. Jonker.

[17] Pulle, Fl. Suriname 1: 481. 1943.

[18] By Jason R. Swallen.

SPOROBOLUS INDICUS (L.) R.Br. SURINAM: frequent, open sandy areas, shrub savanna, Charlesburg Rift, 3 km. north of Paramaribo, *22753*. Mexico and the West Indies to Colombia and Brazil.

CHLORIS RADIATA Swartz. BRITISH GUIANA: New Amsterdam Berbice, *Fraser 356*. Mexico and the West Indies to Bolivia and Argentina.

TRICHACHNE INSULARIS (L.) Nees. SURINAM: frequent, open sandy areas, shrub savanna, Charlesburg Rift, 3 km. north of Paramaribo, *22754*. Southern United States and the West Indies to Argentina.

DIGITARIA ARGILLACEA (Hitchc. & Chase) Fern. BRITISH GUIANA: small tufted annual with few rather dense ascending racemes, Rupununi, *Fraser 363*. The first record for British Guiana. Mexico and the West Indies to Colombia and British Guiana.

ECHINOLAENA INFLEXA (Poir.) Chase. SURINAM: creeping grass with thick reflexed racemes, grass-sedge savanna, Zanderij II, *25042*. Venezuela, Colombia, British and French Guiana and Brazil.

MESOSETUM LOLIIFORME (Hochst.) Chase. BRITISH GUIANA: occasional locally, tufted or stoloniferous with solitary whitish racemes, gravelly soil, Kaieteur Savanna, *23448*. Campos and open sandy woods, Cuba, Trinidad; Venezuela to eastern Brazil.

REIMAROCHOLA ACUTA (Flugge) Hitchc. BRITISH GUIANA: a widely spreading stoloniferous grass, forming dense mats on moist soil on river banks and lake shores, Rupununi, *Fraser 360*. This is the first collection from British Guiana. Venezuela, British Guiana, Brazil, and Paraguay.

AXONOPUS CALULESCENS (Mez) Henr. SURINAM: abundant, joints in bed rock, Savanna I, Tafelberg, *24816*. Described from Mt. Roraima, the only other locality known for this species,

Axonopus flabelliformis Swallen, sp. nov. Perennis; culmi dense caespitosi, erecti, 65 cm. alti, compressi, glabri; vaginae elongatae, equitantes, approximatae, basi 4–5 mm. latae, glabrae; laminae 9–15 cm. longae, 6–8 mm. latae, glabrae; inflorescentiae terminales et axillares; racemi 11–12, adscendentes, 8–10 cm. longi, rhachibus 0.5 mm. latis basi dense pubescentibus marginibus minute scabris; spiculae glabrae 1.6 mm. longae; gluma secunda hyalina obtusa, nervo medio obsoleto; lemma sterile late acutum fructum aequans; fructus flavo-brunneus.

Perennial; culms erect in large clumps, 65 cm. high, compressed, glabrous, the lower part completely covered by the crowded equitant leaves; sheaths strongly compressed, elongate, glabrous, 4–5 mm. or more wide toward the base, the junction with the blade obscure but evident from the outside; blades 9–15 cm. long, those of the lower outer sheaths shorter, conduplicate, 3–4 mm. wide as folded, glabrous, the tip navicular; inflorescences terminal and sometimes axillary; racemes 11–12, rather narrowly ascending, 8–10 cm. long, distributed on the axis 3–4 cm. long, the rachis 0.5 mm. wide, narrowly winged, densely pubescent at the base, the margins and keel between the rows of spikelets minutely scabrous; spikelets 1.6 mm. long, pale; second glume and sterile lemma thin, the glume obtuse, shorter than the fruit, the midnerve suppressed, the lemma broadly acute, as long as or slightly longer than the fruit, weakly nerved; fruit light brown at maturity.

Type: in sandy soil, Half-way station between Wismar and Rockstone, Demerara River, British Guiana, *Hitchcock 17275*.

This species has been referred to *Axonopus attenuatus* (Presl) Hitche. The latter was described from the province of Huanuco, Peru, and differs in several respects. A photograph of the type does not show the conspicuous equitant sheaths of our species, the rachis is scarcely 3 mm. wide, and the spikelets are 2 mm. long with the second glume and sterile lemma equal, pointed beyond the fruit.

F2503 also belongs to *A. flabelliformis*, although the plant is taller and coarser than the type, with 29 racemes as much as 13.5 cm. long. The spikelets are identical.

Axonopus kaietukensis Swallen, sp. nov. Perennis; culmi dense caespitosi, erecti 75–95 cm. alti, paulo compressi, carinati, marginibus dense villosis vel papilloso-villosis; ligula pilosa brevissima; laminae conduplicatae, 15–20 cm. longae, inferiores et superiores reductae, 6 mm. latae, glabrae, marginibus scabris basi dense ciliatis; racemi 8–18, adscendentes, 9–14 cm. longi basi dense pubescentes; spiculae 2 mm. longae, pallidae, ei *A. flabelliformi* similes.

Perennial; culms densely tufted, erect, 75–95 cm. high, somewhat compressed, glabrous; sheaths broad, strongly compressed, keeled, densely villous or papillose-villous on the margins, the junction with the blade not at all evident from outside; ligule a dense line of very short hairs; blades strongly conduplicate, 15–20 cm. long (except the lower ones and the uppermost which are considerably reduced), 3 mm. wide as folded, glabrous on the back, the margins scabrous, densely ciliate toward the base; inflorescences terminal and axillary from the upper sheath; racemes 8–18, rather slender, ascending, 9–14 cm. long, densely pubescent at the base, distributed on the axis 3–5 cm. long, the lowest raceme distant from the others; spikelets 2 mm. long, pale; second glume and sterile lemma thin, almost hyaline, the glume obtuse, slightly shorter than the fruit, the mid-nerve suppressed, the lemma equaling the fruit, acutish; fruit light brown.

TYPE: on dry rocky ground, Kaieteur Savannas, British Guiana, May 14, 1944, *Maguire & Fanshawe 23454*. Known only from the Kaieteur Savannas, and probably endemic. *Tutin 621*, collected in "sandy places with scattered bushes" is the only other specimen known.

This species resembles the preceding but differs in having larger spikelets, longer blades, and shorter sheaths, the latter densely villous on the margins.

Axonopus purpurellus Swallen, sp. nov. Perennis; culmi erecti circa 1 m. alti, paulo compressi, glabri; vaginae carinatae, internodiis longiores, glabrae, marginibus hyalinis; laminae basi conduplicatae, 20–30 cm. longae, 6 mm. latae, scaberulae, marginibus scabris, basi sparse papilloso-ciliatis; racemi 18, angusta adscendentes, rhachibus 0.8 mm. latis, basi minute pubescentibus marginibus scabris; spiculae 1.8 mm. longae, purpurellae, glabrae; gluma et lemma sterile aequalia fructu paulo longiora, sub-acuta; fructus fuscus.

Perennial; culms erect, about 1 m. tall, somewhat compressed, glabrous; sheaths keeled but not strongly compressed, rather loose, longer than the internodes but not crowded, glabrous, the margins hyaline; blades conduplicate, becoming flat, mostly 20–30 cm. long, 3 mm. wide as folded, very gradually narrowed from the base, scaberulous, the margins scabrous, sparsely papillose ciliate at the base; racemes 18, narrowly ascending, the

rachis 0.8 mm. wide, scabrous on the margins, minutely pubescent at the base; spikelets 1.8 mm. long, purplish, glabrous, the second glume and sterile lemma equal, covering the fruit, thin but not hyaline, the mid-nerve of the glume suppressed, of the lemma rather prominent; fruit chestnut brown.

TYPE: on wet sandy soil, km. 68, vicinity of Sectie O, Surinam, October 19, 1944, *Maguire & Stahel 24997*.

Related to the two preceding species, differing in the second glume and sterile lemma being equal, covering the fruit, longer blades which become flat, and the looser, less crowded sheaths. Known only from the type collection.

Paspalum axillare Swallen, sp. nov. Annuum; culmi valde graciles, decubentes, 20–40 cm. longi; vaginae plerumque internodiis breviores, glabrae; ligula 0.5–1 mm. longa, truncata; laminae flaccidae, 4–11 cm. longae, 1–2.5 mm. latae, glabrae; racemus 2.5–3.5 cm. longus, solitarius terminalis et axillaris, pedunculo elongato filiformi, rhachi alata 0.5–0.6 mm. lata; spiculae 1–1.1 mm. longae solitariae pedicellis brevibus scabris; gluma secunda obsoleta; lemma sterile hyalinum, 3-nerve; fructus 1 mm. longus, obovatus, albus, minute striatus.

Weak, very slender annual; culms 20–40 cm. long, decumbent spreading, more or less geniculate at the nodes; sheaths except the lowermost, shorter than the internodes, glabrous, the uppermost bladeless; ligule 0.5–1 mm. long, brownish, truncate; blades lax, 4–11 cm. long, 1–2.5 mm. wide, glabrous; racemes solitary, terminal and axillary from all but the lowermost sheath, borne on elongate filiform peduncles, 2.5–3.5 cm. long, the rachis winged, 0.5–0.6 mm. wide, terminating in a spikelet; spikelets 1–1.1 mm. long, solitary, not crowded, on short scabrous pedicels; first glume wanting; second glume wanting or reduced to a very short nerveless scale; sterile lemma hyaline, very weakly 3-nerved, as long as the fruit; fruit 1 mm. long, slightly obovate, white, very minutely striate.

TYPE: in sand along ledge, moist base of wall, west escarpment, Tafelberg, Surinam, September 10, 1944, *Maguire 24678*.

Belonging to the *Ceresia* group, *P. axillare* differs from all the others in the delicate culms and solitary racemes, these terminal and usually axillary from all but the lowermost sheaths.

Paspalum lucidulum Swallen, sp. nov. Perenne; culmi erecti vel adscendentes, 65 cm. alti, ramosi, compressi, glabri; vaginae carinatae, internodia aequantes, glabrae, marginibus dense ciliatis; ligula truncata 1.5 mm. longa; laminae 15–25 cm. longae, 9–12 mm. latae, acuminatae, lucidulae, sparse pilosae ad basim contractae, supremae reductae; racemi 1 vel 2, arcuati, rhachi alata 1 mm. lata; spiculae obovatae, 2.0–2.1 mm. longae, binae, glabrae; gluma prima 0.4 mm. longa, obtusa vel truncata, enervis; gluma secunda obtusa, 5-nervis, fructum aequans; lemma sterile fructu paulo longior 5-nerve; palea hyalina explicata; fructus 2 mm. longus, obovatus, minute striatus.

Perennial, culms erect or ascending, 65 cm. high, compressed, glabrous, sparingly branched from the upper nodes; sheaths compressed, keeled, glabrous, rather densely ciliate on the margins, about as long as the internodes; ligule brown, truncate, 1.5 mm. long; blades 15–25 cm. long, rather thin, shining, acuminate, sparsely pilose below, sparsely papillose-hispid

above, those of the mid-culm narrowed toward the base to the width of the sheath, the upper blades rounded, somewhat clasping at the base, the uppermost ones much reduced; inflorescence terminal and axillary from the upper sheath, the peduncle 4–6 cm. long, bearing 1 or 2 arcuate racemes, the rachis narrowly winged, about 1 mm. wide; spikelets 2.0–2.1 mm. long, obovate, glabrous, paired, the lower of each pair short-pedicellate, the upper with a pedicel 1 mm. long; first glume present on all spikelets, all alike, 0.4 mm. long, broadly rounded or truncate, nerveless; second glume broadly obtuse, 5-nerved, just covering the fruit and somewhat clasping it; sterile lemma slightly longer than the fruit, 5-nerved, the margins near the summit incurved forming a small hood, the palea well developed, thin, fitting into the incurved margins of the fruit, but without a staminate flower; fruit 2 mm. long, elliptic-obovate, minutely striate.

TYPE: on wet rocky slopes in spray of Grace Falls, Arrowhead Basin, Tafelberg, Surinam, August 26, 1944, *Maguire 24492*.

Related to *P. altsoni* Chase, which differs in having smaller spikelets 1.8 mm. long, and long attenuate blades gradually narrowed toward the base.

PASPALUM PULCHELLUM Kunth. SURINAM: frequent, grass-sedge area, Savanna VI, Tafelberg, *24785*. West Indies; Guatemala to Brazil.

PASPALUM PARVIFLORUM Rohdé. SURINAM: frequent, annual, Savanna II, Tafelberg, *24226*. Puerto Rico; Panamá to Brazil.

PASPALUM LINEARE Trin. BRITISH GUIANA: densely tufted, with short paired racemes of rather large spikelets, Rupununi, *Fraser 355*. This is the first record for this species in British Guiana; also in Brazil and Paraguay.

PASPALUM PLICATULUM Michx. BRITISH GUIANA: Ebeni Experiment Station, *Fraser 365*. Common, southeastern United States and the West Indies to Argentina, although otherwise known in British Guiana only from the Pacaraima Mountains.

PASPALUM MELANOSPERMUM Desv. BRITISH GUIANA: annual, decumbent, more or less weedy grass, in aspect similar to the preceding, Rupununi, *Fraser 361*. Colombia, British and French Guiana, and northern Brazil.

PASPALUM GARDNERIANUM Nees. BRITISH GUIANA: Rupununi, *Fraser 357*. A rather common species on Brazilian grasslands, known elsewhere in British Guiana only from Mt. Roraima; also in Venezuela and Paraguay.

PASPALUM SCANDENS Tutin. BRITISH GUIANA: local, introduced weed, vicinity resthouse, Kaieteur Savannas, *23456* (identified by F. J. Hermann).

PANICUM FASCICULATUM Swartz. BRITISH GUIANA: common widespread weedy grass, with small dark brown spikelets, New Amsterdam Berbice, *Fraser 359*. Southern United States and the West Indies to Ecuador and Brazil.

PANICUM MOLLE Swartz. BRITISH GUIANA: foliage velvety, the spikelets purple, glabrous, a weedy species, Rupununi, *Fraser 364*. Mexico and the West Indies to Argentina.

PANICUM TATEI Swallen. *P. tropidoblephare* Tutin. BRITISH GUIANA: abundant, stiffly erect, with long rigid pungent blades, dominant savanna grass, Kaieteur Savannas, *23399*. Venezuela and British Guiana.

PANICUM PILOSUM Swartz. BRITISH GUIANA: infrequent, in moist soil with sedges, in opening in high forest, Kamuni Creek, Groete Creek, Essequibo River, *22894*. Surinam: locally frequent, joints in bed rocks, Augustus Falls, Tafelberg, *24764*. Mexico and the West Indies to Brazil.

PANICUM LAXUM Swartz. BRITISH GUIANA: locally frequent, in damp sand, Kaieteur Savannas, *23242;* local weed, vicinity of resthouse, Kaieteur Savanna, *23457.* Surinam: along Augustus Creek, Table Mountain, *24735a.* Mexico and the West Indies to Paraguay.

PANICUM FRONDESCENS Meyer. BRITISH GUIANA: frequent, decumbent spreading grass, the culms rooting at the nodes, with sedges in moist soil, in opening in high forest, Kamuni Creek, Groete Creek, Essequibo River, *22893;* swampy ground, Mazaruni Station, *F782.* Mexico to Bolivia and Argentina.

PANICUM STOLONIFERUM Poir. BRITISH GUIANA: river bank between Kangaruma and Amatuk, Potaro River, *23008.* SURINAM: frequent, dense shade, low bush, bordered by *Montrichardia arborescens* and sparse *Drepanocarpus lunatus,* vicinity of Tawa Creek, Saramacca River, *23741.* Mexico to Ecuador and Brazil.

PANICUM NERVOSUM Lam. SURINAM: common, coarse low grass with closely overlapping sheaths and appressed subcordate blades, savanna, Zanderij I, *23722;* wet places, grass-sedge area, Savanna IV, Tafelberg, *24381.* British Guiana, Surinam, and northern Brazil.

PANICUM MICRANTHUM H.B.K. SURINAM: frequent, grass savanna, Zanderij II, *23659.* Venezuela, British Guiana, and Surinam.

Panicum spissifolium Swallen, sp. nov. Perenne; culmi 15–28 cm. alti, erecti vel adscendentes, ramosi, foliosi; vaginae internodiis breviores, glabrae vel sparse pilosae; ligula truncata, 0.3–0.4 mm. longa; laminae erectae 2–3 cm. longae, 2–3.5 mm. latae, plerumque pilosae, vel subtus glabrae; panicula 3–6 cm. longa, ramis adscendentibus vel patentibus; spiculae 1.2 mm. longae, subglobosae, glabrae, purpureae; gluma prima subobtusa quam spicula duplo brevior; gluma secunda obtusa quam spicula paulo brevior; lemma sterile quam spicula paulo longior.

Perennial; culms densely tufted, erect or ascending, 15–28 cm. tall, rather freely branching from the lower nodes, forming a dense mass of foliage at the base of the plant, the lower internodes short, the upper ones longer; sheaths glabrous or sparsely pilose toward the summit, sometimes overlapping but usually shorter than the internodes, the upper ones much shorter than the internodes; ligule hyaline, truncate, about 0.3–0.4 mm. long; blades erect or nearly so, 2–3 cm. long, 2–3.5 mm. wide, bluish-green, glabrous beneath or usually rather conspicuously long-pilose on both surfaces, with prominent white cartilaginous margins; panicles 3–6 cm. long, as broad as long, with slender ascending to spreading branches; spikelets subspherical, purple, glabrous, 1.2 mm. long, on long, very slender divergent pedicels; first glume sub-obtuse, about half as long as the spikelet; second glume obtuse, a little shorter than the fruit; sterile lemma obtuse, slightly longer than the fruit.

TYPE: on rocks in white sand from conglomerate and sandstone, Kaieteur Savannas, British Guiana, April 30, 1944, *Maguire & Fanshawe 23097.*

This species is related to *Panicum micranthum* H.B.K. which differs in having longer acuminate glabrous blades and a lanceolate ligule 1.5 mm. long.

Also referable to this species is *23097a,* which differs only in having taller somewhat more slender culms, with the blades scattered along the culm rather than crowded toward the base.

PANICUM POLYCOMUM Trin. BRITISH GUIANA: locally frequent, small tufted grass, creek bank, Kaieteur Savannas, *23241*. SURINAM: grass savanna, Zanderij II, *23643;* joints in rocky stream bed, Augustus Creek, Tafelberg, *24649*. Venezuela, Colombia, and British Guiana.

PANICUM KAIETUKENSE Tutin. BRITISH GUIANA: locally abundant, erect to decumbent-spreading, with ascending to reflexed blades, in pool 16 cm. deep, with sphagnum, Kaieteur Savanna, *23306*. Described from the Kaieteur Savanna (*Tutin 688*, type); this is the only known collection except the type.

Panicum arctum Swallen, sp. nov. Annuum; culmi graciles erecti, ramosi, 15–30 cm. alti; vaginae internodiis breviores, glabrae vel sparse pilosae; ligula truncata, circiter 0.5 mm. longa; laminae appressae, 3–4.5 cm. longae, 2–3 mm. latae, glabrae, marginibus minute scabris; panicula 4–10 cm. longa, 1–3 cm. lata, ramis filiformibus adscendentibus; spiculae 1.2 mm. longae, glabrae; gluma prima angusta, obtusa, quam spicula duplo brevior; gluma secunda late obtusa, 3-nervis, quam spicula brevior; lemma sterile quam fructu paulo longior, minute apiculatum; fructus 1 mm. longus, lucidus.

Slender annual; culms 15–30 cm. tall, erect or somewhat spreading, rather freely branching from the lower and middle nodes, glabrous; sheaths all shorter than the internodes, glabrous or sparsely papillose-pilose; ligule membranaceous, truncate, about 0.5 mm. long; blades appressed, 3–4.5 cm. long, 2–3 mm. wide, glabrous, with finely scabrous margins; panicles 4–10 cm. long, 1–3 cm. wide, the slender filiform branches rather narrowly ascending; spikelets 1.2 mm. long, glabrous; first glume obtuse, nerveless, less than half as long as the spikelet; second glume very obtuse, 3-nerved, shorter than and exposing the fruit; sterile lemma slightly longer than the fruit, abruptly and minutely pointed; fruit brown, 1 mm. long, shining.

TYPE: in shallow bogs, Savanna I, Tafelberg, Surinam, August 3, 1944, *Maguire 24214*.

Related to *Panicum pyrularium* Hitchc. & Chase which differs in having more conspicuously pyriform spikelets, spreading to reflexed-implicate panicle branches, and broader shorter blades.

Panicum rivale Swallen, sp. nov. Annuum; culmi graciles, erecti, 15 cm. alti, ramosi, glabri; vaginae internodiis plerumque breviores, marginibus sparse pilosae vel papilloso-pilosae; ligula membranacea 1 mm. longa; laminae adscendentes vel patentibus, 2.5–3.3 cm. longae, 4–5 mm. latae, longe pilosae vel fere glabrae; paniculae 3.5–7 cm. longae, pauciflorae, ramis adscendentibus vel patentibus; spiculae 1.2–1.3 mm. longae, subpyriformes, acutae, pedicellis late divergentibus; gluma prima angusta quam spicula duplo brevior; gluma secunda subotusa quam spicula paulo brevior; lemma sterile acutum quam fructu paulo longior; fructus 1 mm. longus, minute stipitatus, minute striatus.

Annual; culms slender, erect, 15 cm. high, simple or usually sparingly branching from the lower nodes, glabrous; sheaths usually shorter than the internodes, sparsely pilose or papillose-pilose toward the summit and on the margins, sometimes nearly glabrous, without a collar, the nerves extending into the blade; ligule membranaceous, about 1 mm. long; blades ascending or spreading, rounded and somewhat clasping at the base, long pilose on both surfaces or nearly glabrous, 2.5–3.3 cm. long, 4–5 mm. wide, the uppermost and those of the branches sometimes reduced; panicles 3.5–7 cm. long, nearly as wide, the few-flowered branches widely ascending, the branchlets

stiffly divergent; spikelets 1.2–1.3 mm. long, elliptic, somewhat pyriform, abruptly acute, on long, filiform, usually widely divergent pedicels; first glume narrow, obtuse, about half as long as the spikelet; second glume obtusish, a little shorter than the fruit; sterile lemma acute, pointed beyond the fruit; fruit 1 mm. long, very minutely stipitate, white, very minutely striate.

TYPE: on banks of lower Augustus Creek, 200 m. above falls, 525 m. altitude, Tafelberg, Surinam, September 13, 1944, *Maguire 24732*.

Panicum rivale is related to the preceding species, differing chiefly in the shorter and broader panicles with more spreading branches and the shorter, broader, and usually spreading blades.

PANICUM ALPOCILIATUM Swallen. *P. pycnoclados* Tutin. BRITISH GUIANA: locally frequent, decumbent, spreading, finally freely branching, the branches short and crowded, Kaieteur Savanna, *23446*. This species was described from Mount Auyantepui, Venezuela. The type specimen is a late branching phase, while *Maguire & Fanshawe* is the early unbranched phase. The type of *P. pycnoclados* is also the branching phase, but the branches are not so numerous nor so crowded. The technical characters of the types are identical.

PANICUM RUDGEI Roem. & Schult. SURINAM: locally abundant, matted, prostrate or scandent, dominant in clearings, swampy bush near Kwatta hede, Saramacca River, *23912*. Venezuela to Bolivia and northern Brazil.

PANICUM MERETENSII Roth. SURINAM: frequent, conspicuous, large panicles with long verticillate branches, marshes, east of Agricultural Experiment Station, Paramaribo, *22711*. Cuba and Trinidad; Mexico to Paraguay.

PANICUM ZIZANIOIDES H.B.K. SURINAM: frequent, marshes, east of Agricultural Experiment Station, Paramaribo, *22712*. Mexico and the West Indies to Paraguay.

ICHNANTHUS AXILLARIS (Nees) Hitchc. & Chase. BRITISH GUIANA: frequent, decumbent-spreading, rooting at the nodes, with small dense short exserted panicles, along trails and in clearings, Kamuni Creek, Groete Creek, Essequibo River, *22843*. SURINAM: frequent in dense shade, low bush bordered by *Montrichardia arborescens* and sparse *Drepanocarpus lunatus*, vicinity of Tawa Creek, Saramacca River, *23742*. Guatemala and the West Indies to Ecuador and Brazil.

ICHNANTHUS PANICOIDES Beauv. BRITISH GUIANA: frequent, broad-leaved woodland grass, with rather dense panicles of large purplish spikelets, in windfall opening in dense second growth, heavy mora forest, Kamuni Creek, Groete Creek, Essequibo River, *22861*. Venezuela, Colombia, Peru, and British Guiana.

ICHNANTHUS RIEDELII (Trin.) Doell. BRITISH GUIANA: occasional, ascending, decumbent-spreading at base, secondary forest, trail from Tukeit to Kaieteur, *23517*. British Guiana, Cayenne, and northern Brazil.

HOMOLEPIS ISOCALYCIA (Meyer) Chase. BRITISH GUIANA: locally frequent, widely decumbent-spreading, rooting at the nodes, stoloniferous, in sand, Kaieteur Savanna, *23287*. Venezuela, Colombia, British Guiana, and Brazil (south to Bahia).

OPLISMENUS HIRTELLUS (L.) Beauv. BRITISH GUIANA: secondary forest on lateritic gravelly soil, Mabaruma, Aruka River, *F2432*. SURINAM: locally

frequent, wet rocks, shaded places at base of cliffs, Augustus Falls, Tafelberg, *24765*. Mexico and the West Indies to Argentina.

LASIACIS LIGULATA Hitchc. & Chase. BRITISH GUIANA: open second-growth forest, Hosorore Hill, Aruka River, *F2391*. SURINAM: frequent, scandent-climbing, opening in high forest, base of north escarpment, Tafelberg, *24315*; Charlesburg Rift, 3 km. north of Paramaribo, *22746*; trail to Coppenam River, rear of Pakka Pakka, *23965*. West Indies; Colombia to Bolivia and Brazil.

SETARIA GENICULATA (Lam.) Beauv. SURINAM: weed, waste places, Kwakoegron, Saramacca River, *25005*. Common in warmer regions throughout the world.

CENCHRUS ECHINATUS L. SURINAM: frequent, along Paramaribo-Carl Francois Road, *23586*. Common weed in warmer regions around the world.

CRYPTOCHLOA CONCINNA (Hook. f.) Swallen. SURINAM: frequent, forest floor, high mixed forest, lower slopes of North Ridge, Table Mountain, *24808*. Nicaragua, Costa Rica, Colombia, and Surinam.

Raddiella Swallen, gen. nov. Monoeca; spiculae masculae et femineae in paniculis separatis dispositae, paniculis masculis terminalibus femineis axillaribus, spicularum pedicellis teretibus; spicula mascula: glumae obsoletae; lemma et palea aequalia, hyalina; lemma 3-nerve, acutum vel subacuminatum; stamina 3; spicula feminea: glumae aequales, acutae, 3-nervae, nervis lateralibus obscuris; fructus ovatus, acutus, induratus; paleae margines plani; annua vel perennis, culmis gracilibus ramosis, laminis planis parvis basi truncatis breve petiolatis.

Staminate and pistillate spikelets on separate inflorescences, the terminal always staminate, the axillary always pistillate; pedicels of spikelets terete, not conspicuously thickened upward, slightly enlarged at the summit forming a minute cup, evident after the disarticulation of the spikelet; staminate spikelet: glumes sometimes evident, usually coalesced with the first joint of the rachilla forming a rounded callus at the base of the spikelet; lemma and palea equal, thin, almost hyaline, the lemma 3-nerved, acute or subacuminate; stamens 3; pistillate spikelet: glumes equal, acute, 3-nerved, the lateral nerves rather faint, adnate at the base to the first joint of the rachilla forming a rounded callus; fruit ovate, acute, indurate, white, smooth, not striate, the margins of the palea flat, not inrolled, entirely enclosing the palea.

Low, branching, often delicate grasses with short deltoid blades.

TYPE SPECIES: *Olyra nana* Doell.

Raddiella nana (Doell) Swallen, comb. nov. *Olyra nana* Doell. BRITISH GUIANA: slender, wiry, tufted grass to 15 cm. high, locally common in sedge bog, Kaieteur Savanna, *23109*. SURINAM: infrequent, wet places, border of low forest, Savanna I, Tafelberg, *24388*. Trinidad, Venezuela, British Guiana, Surinam, and Brazil.

Raddiella Malmeana (Ekman) Swallen, comb. nov. *Olyra Malmeana* Ekman. BRITISH GUIANA: locally common, delicate, pale green, on moist rocks in mixed forest, high level plateau, trail from Tukeit to Kaieteur Plateau, Potaro River Gorge, *23087*. SURINAM: abundant, under drips, base of north escarpment, Tafelberg, *24327*. British Guiana and Brazil.

Raddiella truncata Swallen, sp. nov. Perennis; culmi 15–20 cm. alti, adscendentes, glabri; vaginae internodiis longiores vel frequentes duplo

breviores, glabrae, truncatae; ligula brevissima; laminae 1.5–2.5 cm. longae, 7–10 mm. latae, minute apiculatae, marginibus scabrae; spiculae masculae non visae; spiculae femineae 2.7 mm. longae, ellipticae, subacutae, dense pubescentes.

Perennial; culms in small tufts, ascending or spreading, 15–20 cm. high, glabrous; sheaths overlapping or frequently half as long as the internodes, glabrous, the summit truncate; ligule reduced to a short minutely ciliate rim; blades subsessile, roughly triangular, 1.5–2.5 cm. long, mostly 7–10 mm. wide at the base, obtuse, with a minute point at the tip, glabrous, the margins scabrous; panicles terminal and axillary from the upper sheaths, the terminal apparently staminate, the axillary pistillate, the terminal about 2 cm. long, scarcely exserted from the sheath, the short branches ascending, the axillary pistillate panicles few-flowered, partly included in the sheath; staminate spikelets unknown; pistillate spikelets 2.7 mm. long, elliptic, bluntly pointed, rather densely pubescent.

TYPE: in secondary forest, on white sand, Waratuk Falls, Potaro River Gorge, April 27, 1944, *Maguire & Fanshawe 23035*.

OLYRA LATERALIS (Presl.) Chase. SURINAM: infrequent, climbing on dripping cliffs, west of Grace Falls, Arrowhead Basin, Tafelberg, *24501*. Costa Rica: Colombia to Surinam and Bolivia.

OLYRA LATIFOLIA L. SURINAM: frequent, climbing in primary jungle, 3 km. north of Paramaribo, *22795*. Common, Mexico and the West Indies to Bolivia and Argentina; Africa.

OLYRA CORDIFOLIA H.B.K. BRITISH GUIANA: Barbara Creek, Lower Essequibo River, *F939*. SURINAM: frequent, primary jungle near village, Posoegronoe, Saramacca River, *24032a*. Venezuela to Peru and northern Brazil.

OLYRA OBLIQUIFOLIA Steud. SURINAM: frequent, 1.5 m. high, forming loose clumps, high bush, 0.5 km. south of East Ridge, Tafelberg, *24595;* near village, Posoegronoe, Saramacca River, *24032*. Surinam and northern Brazil.

OLYRA LONGIFOLIA H.B.K. *O. surinamensis* Hochst. BRITISH GUIANA: lax straggling grass in small clumps, 4–5 feet long, creek fringe, Bunsika Creek, Aruwau Creek, Aruka River, *F2445*. Unlike other species of *Olyra* the staminate spikelets are on one of two branches of the inflorescence and the pistillate on the other. Venezuela to Peru and northern Brazil.

OLYRA MICRANTHA H.B.K. SURINAM: frequent, tall, coarse, broad-leaved grass, with dense panicles of small spikelets, damp places, base of south cliffs, high forest, Arrowhead Basin, Tafelberg, *24456;* infrequent, deep shade of heavy bush, rocky slope, river banks below rapids, Jacob kondre, Saramacca River, *23826;* frequent, secondary bush, Zanderij II, *23707*. Venezuela to British Guiana and Paraguay. These are apparently the first collections of this species from Surinam. Colombia to Surinam, Bolivia, and Argentina.

PARIANA LONGIFLORA Tutin. BRITISH GUIANA: frequent, widely creeping grass with leafy sterile culms and leafless fertile culms, forest floor, mora and mixed forest, Kamuni Creek, Groete Creek, Essequibo River, *22829*. British Guiana (Mazaruni Station, type [*Tutin 39*]) and northern Brazil (Mosqueira, Pará [*Swallen 4868*]). These three are the only specimens known of this species.

PARIANA ZINGIBERINA Doell. BRITISH GUIANA: in large clumps in riparian forest, the leafy sterile culms tall, the leafless sterile culms short, hidden in the foliage, Takutu Creek to Puruni River, Mazaruni River, *F2150*. Venezuela and British Guiana.

PHARUS LATIFOLIUS L. SURINAM: infrequent, erect, broad-leaved woodland grass, shady bush, trail to rear of village, Jacob kondre, *32892*. Widely distributed in moist forests, Central America, the West Indies, and northern South America.

PHARUS PARVIFOLIA Nash. SURINAM: locally frequent, creeping, wet rocks, shaded places at base of cliffs, Augusta Falls, Tafelberg, *24766*. Mexico and the West Indies to Brazil.

ANDROPOGON BICORNIS L. BRITISH GUIANA: occasional, coarse, densely tufted grass with conspicuous white plume-like inflorescence, between bush islands on Kaieteur Savanna, *23404*; dry rocks, trail from Kaieteur to Tukeit, *23473*. Southern Mexico and the West Indies to Bolivia and Argentina.

ANDROPOGON ANGUSTATUS (Presl.) Steud. SURINAM: frequent on rocks, Gran dam Saramacca River, *24935*. Cuba; Mexico to Brazil.

CYPERACEAE[20]

The striking characteristic of this interesting collection of sedges is the broad iris-like nature of the leaves, to be observed especially in such genera as *Mapania, Diplasia, Becquerelia,* and even in *Rynchospora*. Many are inhabitants of swamps, and that environment may perhaps account for the convergent evolution of equitant leaves in several genera. At any rate, the mountainous areas of British Guiana and Surinam are among the world's most interesting places for Cyperaceae, and the localized species to be found there present difficult problems in identification. The chief relationship of the restricted species seems to be with the uplands of eastern Brazil; some genera such as *Mapania, Hypolytrum,* and *Trilepis,* are primarily African or Asian. Our knowledge of the cyperaceous flora of British Guiana is based on fragmentary reports by a number of botanists. For Surinam, there is fortunately a comprehensive account of Uittien in Pulle's *Flora of Surinam*, vol. 1, p. 72–149 (1934), and I have referred to his treatment of species by citing the page number in parentheses. Only a relatively small area of Surinam and British Guiana has been explored, and the number of Cyperaceae will undoubtedly be much extended through further exploration.

CYPERUS DIFFUSUS Vahl (84). SURINAM: perennial with long culms, numerous long leaf-like bracts surrounding the sparsely branched radiate inflorescence, frequent, in shaded bush trails above Kwatta hede, Saramacca River, *23950*. Mexico to Argentina and in the Old World tropics.

CYPERUS DIFFUSUS var. TOLUCENSIS (H.B.K.) Kükenth. SURINAM: with broader leaves and more branched inflorescence, frequent, in clearings, Charlesburg Rift, 3 km. north of Paramaribo, *22740*. Mexico to Bolivia.

CYPERUS FLAVUS (Vahl) Nees. *C. cayennensis* (Lam.) Britton (93). BRITISH GUIANA: perennial with short thickened rhizomes and dense cylindric sessile spikes, occasional along Potaro River, *22999*. An abundant plant from southern United States to Argentina.

CYPERUS GIGANTEUS Vahl (90). BRITISH GUIANA: aquatic with leaf-

[20] By Henry K. Svenson.

less culms to 2.5 m. high, in river tidal flats, Mazaruni Forest Station, *23567*. Mexico to Argentina.

CYPERUS LUZULAE Retz. (85). BRITISH GUIANA: perennial with short woody rhizomes, the small flattened spikelets glomerulate in a compound inflorescence, frequent in wet forest openings, Kamuni Creek, Essequibo River, *22896*. SURINAM: clearings, Charlesburg Rift, 3 km. north of Paramaribo, *22730*. Abundant from West Indies to Paraguay.

CYPERUS POLYSTACHYUS Rottb. (78). SURINAM: annual with short leaves, pale green to yellow spikelets in compound spikes, frequent in sand in clearings, Charlesburg Rift, *22736, 22737*. Abundant in all tropical and warm temperate countries throughout the world.

CYPERUS SIMPLEX HBK. (82). SURINAM: low perennial with rays much longer than the culms, frequent in open areas along trail, Jacob kondre, Saramacca River, *23753*. Southern Mexico to Brazil and Bolivia.

CYPERUS SUBUMBELLATUS Kükenth. *Mariscus umbellatus* Vahl (92). SURINAM: perennial with densely cylindric spikes on long rays, frequent in sand, clearings, Charlesburg Rift, *22731*. Tropical Africa and Madagascar; occasionally introduced in the West Indies. It was collected by Lanjouw at Paramaribo.

CYPERUS SURINAMENSIS Rottb. (84). SURINAM: perennial with slender rough culms, compound umbels with small flattened spikelets, frequent in sand, clearings, Charlesburg Rift, *22735*. Abundantly distributed from Florida to Argentina.

KYLLINGA PUNGENS Link (76). SURINAM: frequent perennial with coarse creeping rootstocks, rigid culms and bracts, in sand north of Paramaribo, *22751*. Tropical America and West Africa.

HEMICARPHA MICRANTHA (Vahl) Britton (126). SURINAM: frequent in sand banks along railroad bed, Kwakoegron, *23775;* weed in sand about Kwatta hede, Saramacca River, *23951*. The plants are robust (15 cm. high) but otherwise the same as the type of *Scirpus micranthus*, which I examined in Vahl's herbarium in 1937. The type is a single small plant 6 cm. high, with spikelets 3–4 mm. long, the somewhat mucronate scales rather closely appressed to the achene, with only the tips divergent. The achenes average 0.67×0.3 mm. The collection (from Jussieu) came from South America, possibly from the coast of Peru, where I collected similar material in 1941, and where Jussieu was known to have collected extensively. No. 23951 shows occasional acicular remains of reduced scales which can be readily made out with a binocular. These are most frequent above the middle of the spikelet. Widely distributed in North and South America.

SCIRPUS CUBENSIS Poeppig & Kunth. BRITISH GUIANA: semi-aquatic sedge forming pure clumps 10–20 feet in diameter by river bank in places where there are habitations—spreading by runners, flowers brownish-green, Mt. Everard, Barima River, British Guiana, *F2351*. Known from Central America and the West Indies to Argentina; tropical Africa.

ELEOCHARIS GENICULATA (L.) R. & S. (113). BRITISH GUIANA: the coarse culms have prominent cross-bars, and the many-flowered inflorescence is brownish, river tidal flats, Mazaruni Forest Station, *23574*. Of wide range in tropical America.

ELEOCHARIS INTERSTINCTA (Vahl) R. & S. (110). SURINAM: Kwakoegron, *25010;* wet sand, Zanderij II, *25032*. Resembles *E. geniculata* but has coriaceous yellow appressed scales. Distribution as in *E. geniculata*.

ELEOCHARIS cf. SUBFOLIATA Clarke. SURINAM: small aquatic in flowing water, lower Augustus Creek, Tafelberg, *24729;* Geijskes Creek, Tafelberg, *24834;* wet sand, Grasi Falls, Saramacca River, *24944.* No achenes are present; *E. subfoliata* is known only from British Guiana and adjacent Brazil.

FUIRENA UMBELLATA Rottb. (124). SURINAM: a tall plant with 4-angled stem, in wet sand, Zanderij II, *25031.* Widely distributed in the American tropics.

BULBOSTYLIS JUNCIFORMIS (HBK) Lindman (118). BRITISH GUIANA: Ituni Road, Demerara River, *F2504.* SURINAM: a nearly glabrous wiry perennial in savannas, Zanderij I, *23727, 24977.* Widely distributed from Mexico and the West Indies to eastern Brazil.

BULBOSTYLIS LANATA (HBK) Clarke (115). SURINAM: perennial with an enormous woody base, resembling *B. paradoxa* but with the rhizome apex woolly and scales obtuse, savannas in vicinity of Arawak village, *24968.* Known also from Venezuela and British Guiana.

FIMBRISTYLIS ANNUA var. DIPHYLLA (Retz) Kükenth. (122). BRITISH GUIANA: Garraway Stream, Potaro River, *22987;* tufted rock plants in white sand, Kaieteur Savanna, *23118.* Widely distributed as a weedy plant in all tropical regions.

FIMBRISTYLIS ASPERA (Schrader) Böck. BRITISH GUIANA: tufted sedge to 70 cm. high, long coriaceous equitant leaves 6–8 mm wide, and shiny chocolate-brown leaf bases, on river bank, Kaieteur Savanna, *23222.* This is a rare plant known previously only from eastern Brazil.

FIMBRISTYLIS COMPLANATA (Retz.) Link (123). SURINAM: annual with soft compressed culms, in ditches of savanna, vicinity Sectie O, km. 68, *25028.* Widely distributed in the tropics.

FIMBRISTYLIS MILIACEA (L.) Vahl (123). BRITISH GUIANA: opening along Kamuni Creek, Groete Creek, Essequibo River, *22895.* SURINAM: a common tropical weed with small spherical spikelets, in wet places, Experiment Station, Paramaribo, *22709.*

RYNCHOSPORA ARENICOLA Uitt. (101). BRITISH GUIANA: cespitose perennial with narrow coriaceous leaves, the long culms each with a single globose head, common in Kaieteur Savannas, *23115.* SURINAM: infrequent, in sand, savanna, Zanderij I, *23729a. R. arenicola* has previously been considered endemic to Surinam. It is distinguished by Uittien from *R. pilosa* Boeckl., of eastern and southern Brazil, only by the sparse pubescence and large pale spikelets.

RYNCHOSPORA BARBATA (Vahl) Kunth. (100). BRITISH GUIANA: tufted glabrous perennial, each culm with a single globular head, frequent rock plant, in white sands, Kaieteur Savannas, *23098.* SURINM: common, Savanna II, Tafelberg, *24224;* savanna, Zanderij II, *23669.* One of the commonest tropical American species of *Rynchospora,* extending from Panama and the West Indies to Brazil.

RYNCHOSPORA CEPHALOTES Vahl (106). BRITISH GUIANA: occasional to frequent tufted perennial, the inflorescence varying from capitate to elongate-paniculate, in forest or rocky openings, Amatuk Portage, *23025;* Kaieteur Savannas, *23324.* SURINAM: Arrowhead Basin, Tafelberg, *24493;* 1 km. southeast of Savanna VIII, Tafelberg, *24550;* Tawa Creek, Saramacca River, *23746;* banks Geijskes Creek, high mixed wallaba forest, km. 17, Black Water Camp (5), *24847.* The most common forest *Rynchospora* of tropical America.

RYNCHOSPORA COMATA Schultes (107). SURINAM: infrequent, in montane forest, vicinity Krappa Camp (2), Saramacca River Headwaters, *24138*. This plant (sect. *Psilocarya*) has the general appearance of *R. cephalotes* except that it has a loose corymb of large individual spikelets.

RYNCHOSPORA CURVULA Griseb. BRITISH GUIANA: annual with spreading filiform culms in damp sand, Kaieteur Savannas, *23312*. A little plant with the aspect of *Carex pauciflora*, known only from Surinam, British Guiana, and Trinidad. (cf. Uittien, *Additions to Pulle's Flora of Surinam* 1, p. 30. 1935 [Rec. Trav. Bot. Néerl. 32].)

RYNCHOSPORA CYPEROIDES (Sw.) Mart. (102). SURINAM: frequent annual with a spreading inflorescence of long-rayed globular heads, in coastal jungle along Saramacca River, 79 km. from Paramaribo, *23600a;* in white sand, Zanderij II, *25029, 23648*. Widespread in tropical Africa and tropical America.

RYNCHOSPORA GRAMINEA Uitt. (p. 105) and Rec. Trav. Bot. Néerl. **32**: 219 (1935). *R. longispicata* Clarke; Urban. Symb. Ant. **2**: 122 (1900), not Böck. (1873). *R. filiformis* var. *latifolia* Uittien. The linear spikelets (ca. 7 mm. long) are in a diffuse corymb. Uittien knew this species as endemic to Surinam from collections by Pulle and Essed in the savanna of Zanderij, but suspected it to be of wider distribution. Maguire finds it frequent in the grass savanna, Zanderij II, *23675*, and also has it from dry sands in the Kaieteur Savannas of British Guiana, *23308*.

RYNCHOSPORA TENELLA (Nees) Böckl. (108). SURINAM: a dwarf annual with the aspect of slender *Fimbristylis autumnalis*, infrequent in shallow sand, Savanna II, Tafelberg, *24251*. Described from banks of the Apapuris River in Brazil (close to the southeastern boundary of Colombia); otherwise known only from Surinam.

RYNCHOSPORA TENUIS Link (104). BRITISH GUIANA: procumbent tufted annual with filiform leaves and pale brown corymbose inflorescence, locally frequent in dry sand, Kaieteur Savannas, *23163, 23307*. A widespread species from Mexico and the West Indies to Argentina. In the Surinam collections it is represented by var. *maritima* Boeckl., with larger congested spikelets and apparently perennial culm bases with more extensive fibrous roots; wet sands, Savanna II, Tafelberg, *24251a* (diseased, with no achenes), and Zanderij II, *25030*. Some plants of the latter collection are identical with *la Cruz 4350*, from the Upper Mazaruni River, named by N. E. Brown as *R. riparia* Böck. (based on a Pohl collection from Goyaz, Brazil). Achenes of *25030* are typically those of *Rynchospora tenuis*. The variety is cited by Böckeler from Brazil, Mexico, and Surinam, and the name comes from "*Schoenus maritimus* Salzm. Lindl. herb." Since *Haloschoenus capillaris* var. *congestus* Nees is given as a synonym by Böckeler, a change in the varietal name will probably be necessary when taxonomic difficulties have been cleared.

DICHROMENA CILIATA Vahl (97). SURINAM: perennial with whitened bracts surrounding a terminal cluster of spikelets, frequent in marshes and borders of swamps, Charlesburg Rift, north of Paramaribo, *22721*. Widely distributed in tropical America.

DICHROMENA PUBERA Vahl (96). BRITISH GUIANA: Garraway Stream, Potaro River, *22998*. SURINAM: grass savanna, Zanderij II, *23664*. Possibly annual, with shorter leaves than in *D. ciliata*, from which it differs chiefly

in the pubescent spikelets and more sharply ridged achenes. Widely distributed in tropical South America, but less frequent than *D. ciliata.*

DICHROMENA REPENS Vahl (96). SURINAM: a slender annual (?) with decumbent rooting stems, and scarcely whitened bracts, Gran dam, Saramacca River, *24924.* Known only from the Guianas.

DIPLASIA KARATAEFOLIA L. C. Rich. (127). A gigantic sedge with broad coriaceous leaves and cylindric spikes on elongate rays. The achene is about 6 mm. long with the form of an oat grain. BRITISH GUIANA: frequent, Kamuni Creek, Groete Creek, Essequibo River, *22850.* SURINAM: secondary bush, Zanderij II, *23647, 23708.*

MAPANIA SYLVATICA Aubl. (128). Herb with leafless culms, each surmounted by three broad-leaved bracts enclosing the inflorescence. BRITISH GUIANA: locally frequent on forest floor, Kamuni Creek, Groete Creek, Essequibo River, *22831.* SURINAM: frequent in low forest, line beyond Pakira Camp (4), Coppenam River Headwaters, *24167.* Compression of the spikelets in *Mapania* and associated genera has made the interpretation of the actual structure very difficult. It seems clear to me that a single terminal flower is represented, and not a group of flowers, and that the scales are alternate in arrangement with the three stamens. The other, and I believe incorrect, interpretation is that each stamen and associated bract is a distinct flower. Two of the outer series of scales are greatly strongly compressed laterally and ciliated much as in the genus *Xyris.* So far as attachment of filaments is concerned, the flower of typical *Mapania* would appear to be a perfectly normal representative of the Cyperaceae. *M. sylvatica* is known from Costa Rica and Panama to Venezuela and the Guianas. This illustration (fig. 3B), based on *Maguire 24167,* shows (*a*) a single flower much magnified; (*b*) a diagrammatic section of a flower, showing its compressed nature and relation of the scales and stamens; (*c*) a mature achene and three-parted style.

MAPANIA aff. PYCNOCEPHALA Benth. (Fig. 4.) SURINAM: broad-leaved plants about 1 m. high, with firm trigonous culms, and with glistening castaneous leaf-bases, locally common, in swamps, at top of North Ridge, Tafelberg, *24242. M. pycnocephala* was described from Gorgona Island off the west coast of Colombia, and has been cited by Standley from Costa Rica. The illustration by Clarke (Ill. Cyp. *pl. 113*) shows a plant with much less compact inflorescence and with only two stamens. The almost tubular inrollment of scales about the stamens makes it difficult to determine whether these scales are actually alternate with the stamens or opposite them. If they are alternate, the flower is a terminal one, and no different in its structure than that of *Mapania sylvatica* (the type species of the genus) except that two of the outer scales are lacking. Our illustration, based on *Maguire 24242,* shows (*a*) a fragment of the inflorescence with a number of spikelets, (*b*) an achene, (*c*) a single flower, (*d*) a diagrammatic cross-section of a flower, showing the large enveloping outer bract, the axial bract adjacent to the style, and the three bracts each enclosing a staminal filament.

No. 24242 probably represents *M. surinamensis* Uittien, in Pulle's Fl. Surinam 1: 128 (1934; *M. montana* Uittien, not Ridley), which is known only from Mt. Hendrik Top and the Wilhelmina Mountains, Surinam, with which it agrees, at least partly, in flower structure.

MAPANIA MACROPHYLLA (Bock.) H. Pfeiff. *M. Schomburgkii* Clarke

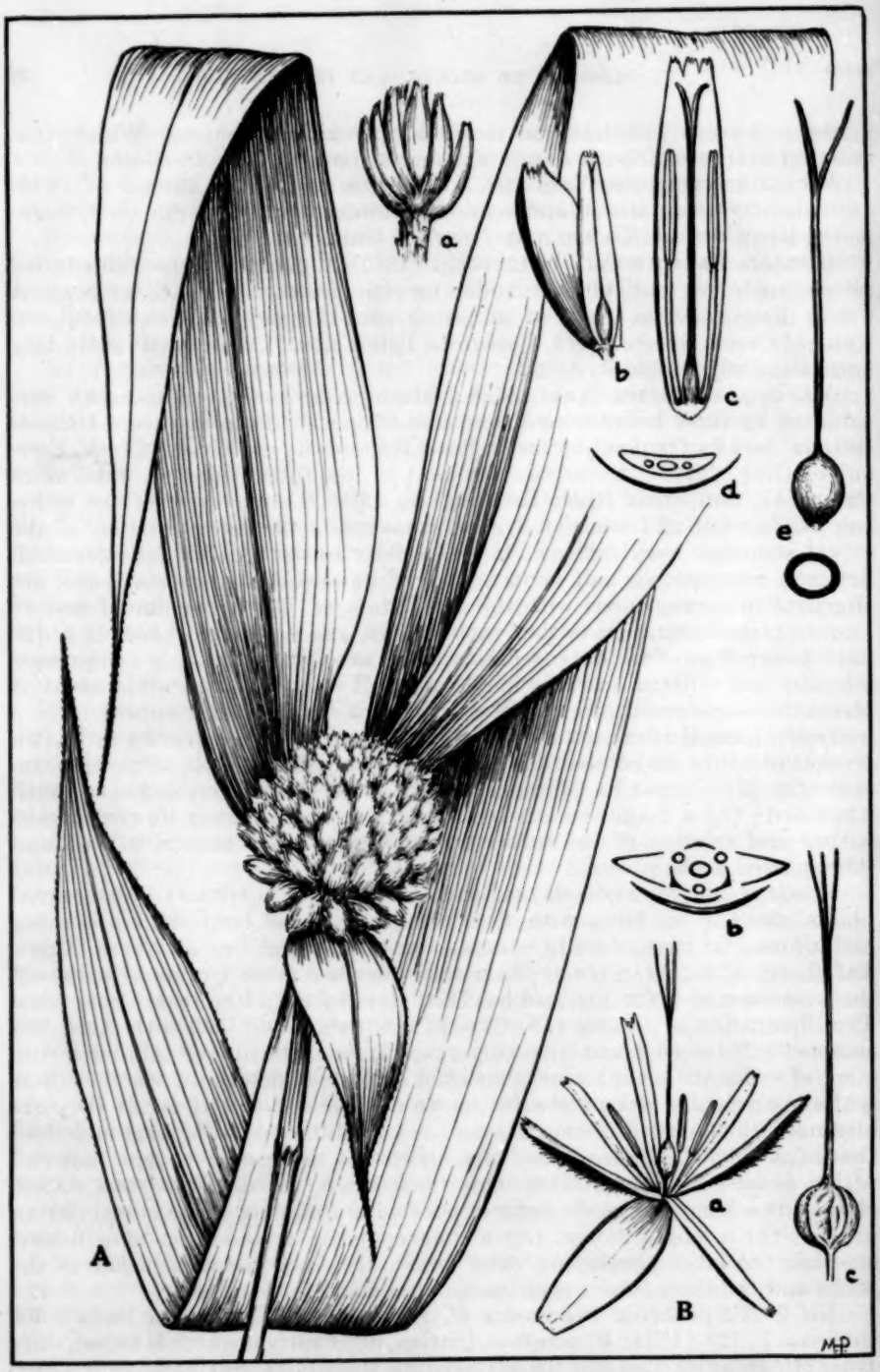


FIG. 3. A. *Mapania macrophylla* (Böck.) H. Pfeiff. *Maguire & Fanshawe 23017*, in fruit; *23545*, in flower. *a*, a fragment of one of the "spikelets." *b*, a flower with accompanying scale. *c*, a flower as seen through the transparent "corolla." *d*, a cross-section of the flower with adjacent bract. *e*, fruit (with style) and its cross-section. B. *Mapania sylvatica* Aubl. *Maguire 24167*. *a*, a single flower much amplified. *b*, a diagrammatic section of a flower, showing the compressed nature and relation of scale and stamen. *c*, a mature achene and 3-parted style.

(128). (Fig. 3A.) BRITISH GUIANA: Perennial tufted herb to 2 m. high, with broad basal leaves, naked culms, and 3 bracts (the largest as much as 8 cm. broad) ending in acuminate sharp-toothed apices; occasional in marshy areas in white sand, in secondary scrub forest, Amatuk Portage, Potaro River, *23017* (in fruit); *23545* (in flower); in wet dicymbe forest, Warratuk Portage, Potaro River, *23539* (in fruit).

All these appear to be the same and to coincide with Schomburgk's collection, though the spikelets rapidly disintegrate and their structure is not discernible in the fruiting stage. This certainly is one of the most remarkable and primitive members of the Cyperaceae—it cannot belong to any other family. The strongly flattened delicate and transparent lacerate-tipped "corolla" is 9.5 mm. long, the stamens 3.5 mm. long. Sandwith, Kew Bull. **1933**: 496, has described *M. insignis* from the Potaro River (based on *Jenman 7478*). The description of this species agrees in general with Maguire's collections, but is described as having 3 stamens, each 2.2–3 mm. long, and four scales, 9–11 mm. long, the two lateral flattened and keeled, the keel entirely smooth. It is quite possible that the membranous "corolla" splits up later to form structures as described by Sandwith, but I have not been able to see such a transformation. Uittien says of *M. macrophylla* (p. 129), "Glumes 1 cm. long. Flowers with only one large petal. Stamen 1." Clarke's figure (Ill. Cyp. *pl. 113*) was drawn from a Schomburgk specimen, but shows only the fruit. Pfeiffer, Rep. Spec. Nov. **28**: 22 (1930), notes that the species is imperfectly known with "squamellae 6 (?), albidae, cum maxima parte glumae aequilongae." *M. macroprylla* is known from San Domingo and British Guiana.

Our illustration shows (*a*) a fragment of one of the "spikelets"; (*b*) a flower with accompanying scale; (*c*) a flower as seen through the transparent "corolla"; (*d*) a cross-section of the flower with adjacent bract; (*e*) fruit (with style) and its cross-section.

HYPOLYTRUM PULCHRUM (Rudge) Pfeiffer, Bot. Arch. **12**: 450. 1925. *H. pungens* (Vahl) Kunth. *H. rigens* Nees (p. 130). SURINAM: perennial with elongate scale rhizomes and narrow inrolled triquetrous leaves not exceeding 4 mm. in width, the head composed of 6–15 oblong spikelets; in savannas, Arawak village Mata, *24974;* vicinity Sectie O, km. 68, *25012;* in grass savanna, Zanderij II, *23649*. Specimens agree with Schweinitz's collection from Surinam, with *Hitchcock 10949* from Georgetown, and with *Tate 1366* from Auyan-tepui, Venezuela. Known from the Guianas, Venezuela, and from Minas Geraes, Brazil.

HYPOLYTRUM sp. SURINAM: perennial, apparently with a vertical rhizome; culms 1.5–4.5 dm. high, mostly leafless, covered at the base by the dilated red leaf-sheaths; leaves acuminate, exceeding the culms, 10–25 mm. broad, the base narrowed into a petiole; locally common in swamps, Savanna I, Tafelberg, *24364;* frequent on stony banks of lower Augustus Creek, Tafelberg, *24730*.

No. *24364* has a large pseudo-corymbose long-bracteate inflorescence reminiscent of *Eryngium*. The 8 main heads (1–1.5 cm. diam.) are on rays up to 4 cm. long, each with 2 or 3 satellite heads on short reflexed rays, and are composed of very numerous, small, 1-flowered flattened spikelets, from which the prominent whitened tips of the achenes protrude. In no. *24730*, which has slender culms not exceeding 2 dm., the inflorescence is reduced

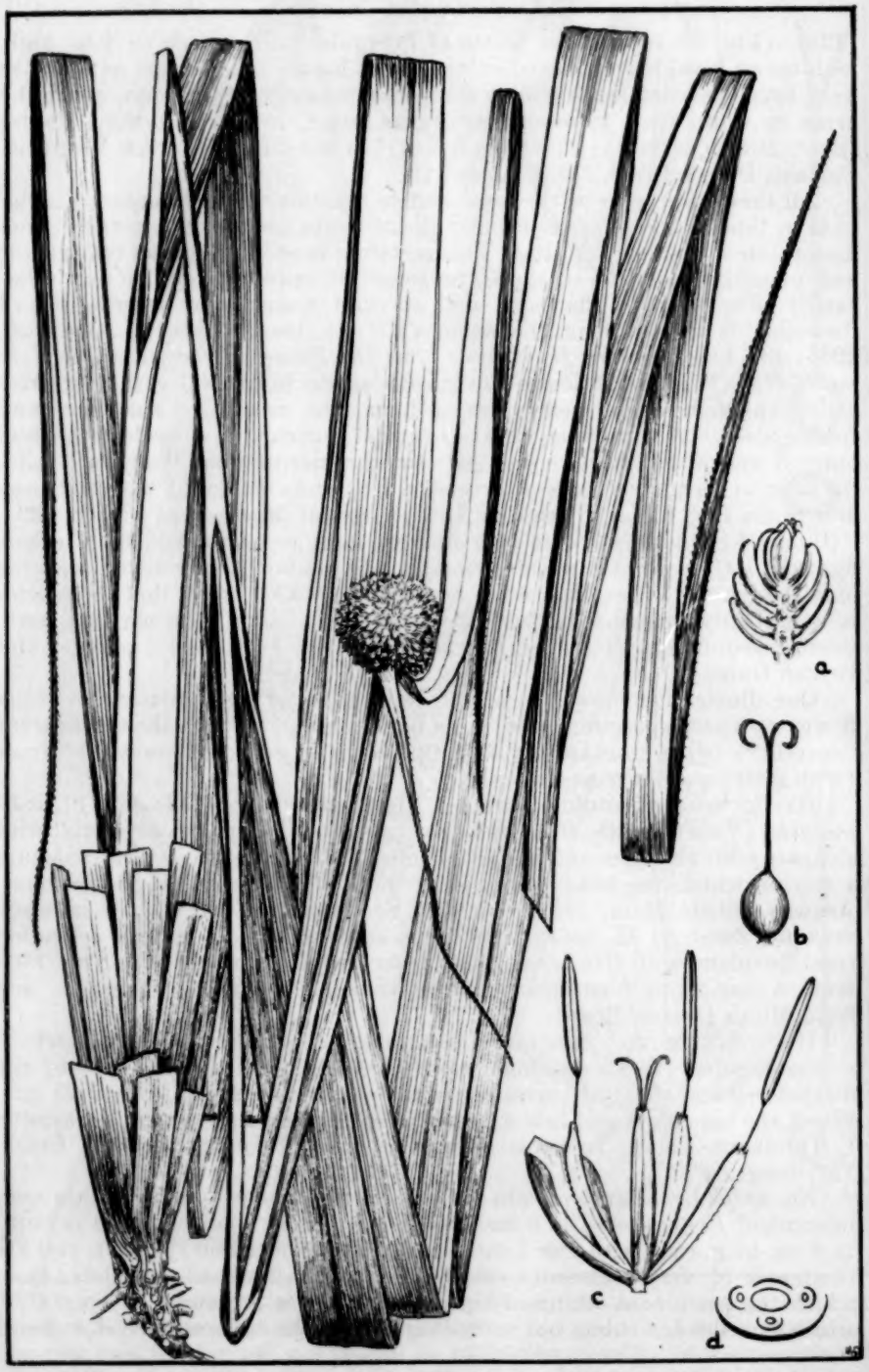


FIG. 4. *Mapania* aff. *pycnocephala* Benth. *Maguire 24242*. *a*, a fragment of an inflorescence with a number of spikelets. *b*, an achene. *c*, a single flower. *d*, a diagrammatic cross-section of a flower.

to a nearly capitate form. Each spikelet consists of a thin bract 2.5 mm. long, and 3 similar brown scales each 3 mm. in length. These 3 scales vary greatly in width, and 2 of them are sometimes united to form a sort of tube; none of them show any ciliation or thickening of the keel. The biconvex achenes, 3.5 mm. long and 1–1.5 mm. wide, have $\frac{2}{3}$ of their length occupied by a soft, pale gray, spongy beak, streaked with brown. The thick-walled, orbicular achene-body is smooth and pale yellow. There are 2 stamens and the style is 2-parted to the base. The long beak of the achene is somewhat similar to that of *H. strictum* Kunth, as illustrated by Clarke (Ill. Cyp. *pl. 103, fig. 18*); otherwise the plants have little in common. I have not seen any specimens similar to Maguire's and perhaps they represent a new species; but the species already described within this genus are too poorly known for adequate reference.

SCLERIA ARUNDINACEA Kunth, Enum. **2**: 347. 1837. BRITISH GUIANA: sedge with winged stems to 6 feet tall, broad leaves (4 cm. wide) and depressed-globose, white-to-purplish achenes, on lateritic soil, Mabaruma, Aruka River, *Fanshawe 2356*. Abundant in forest clearings from Central America and the West Indies to Argentina. This species is united with *S. latifolia* Sw. by Uittien (p. 143); Core is also of the opinion that the two species are perhaps not distinct.

SCLERIA MACROGYNE Clarke. Perennial, in clumps to 1 m. tall, the sheath-ligules with a prominent scarious margin. BRITISH GUIANA: Kangaruma, Potaro River, *23002a;* Kaieteur Savanna, *23104*. SURINAM: in thickets, among shrubs, or along borders of Savanna I, Tafelberg, *24398*.

Uittien and Core differ on disposal of names in this difficult *Hymenolytrum* group. Clarke thought that British Guiana material (*S. macrogyne*) differed from the Brazilian *Hymenolytrum Martii* Nees in having a sharply-angled achene, but Uittien has described the achene of *S. Martii* also as trigonous and resembling a grain of buckwheat. The real question is whether Nees' illustration of *H. Martii*, in which the achene has rather blunt angles, really represents mature fruit—it probably does not. Core thinks that *Scleria violacea* Pilger—a photograph of which to me appears identical with *24398*—should probably be called *Scleria Martii* (Nees) Steudel; and *23002a* certainly belongs with Uittien's description of *S. Martii*. From *23002a, 24398* differs in its smoother culms and purple panicle with smaller blunter achenes. By Uittien this latter specimen would probably be treated as *S. pyramidalis* Hochst, and by Core as *S. violacea* Pilger. *23104* is very immature, but the veining of the ligule is exactly that of *24398*. I have followed Core in treating the Guiana material of these widespread plants as *S. macrogyne*.

SCLERIA MICROCOCCA (Liebm.) Steud. *S. Liebmanni* Steud. (135). SURINAM: infrequent annual with verticillate inflorescence, in open places, Savanna II, Tafelberg, *24250a, 24250* (frequent). Ranges from Mexico and Cuba to southern Brazil.

SCLERIA MITIS Bergius (142). SURINAM: a wide-leaved species with narrow elongate inflorescence and white achenes only 2 mm. wide, common in clearings, Lamke kondre, Saramacca River, *23903*. Known from the West Indies and Panama to southern Brazil.

SCLERIA PTEROTA Presl (140). SURINAM: 3 km. north of Paramaribo, *22747;* frequent in secondary jungle, along stream, Jacob kondre, *23839* (var. *melaleuca* [Schlecht.] Uitt.). Perhaps the most abundant species of

Scleria in the American tropics, forming erect clumps a foot or two in height. The achenes vary from white to deep purple.

SCLERIA SECANS (L.) Urb. (139). SURINAM: frequent, the slender saw-toothed stems climb over the underbrush, primary jungle, 3 km. north of Paramaribo, *22796*. Wide tropical distribution.

BECQUERELIA CYMOSA Brongn. (144). A large broad-leaved perennial resembling *Scleria*, but with the achenes surrounded by bracts much in the manner of *Diplacrum*. SURINAM: in swampy bush above village of Jacob kondre, Saramacca River, *33839a*. Widely distributed from the West Indies to the Guianas and Brazil.

BISBOECKELERA LONGIFOLIA (Rudge) Standley (145). BRITISH GUIANA: a broad-leaved low perennial, with small (5 mm. long) cream-colored flower heads, locally frequent, in dicymbe forest, Tukeit, Potaro River, *23538*. *Bisboeckelera* is the old genus *Hoppia*, in which a perigynium analogous (but probably not homologous) to that of *Carex*, surrounds the achene. The genus is exceedingly close to *Calyptrocarya*, which it resembles in general aspect. Uittien says that *B. longifolia* is endemic to Surinam, but it is well known that Rudge's specimens were collected in French Guiana by Joseph Martin, who was a garden director at Cayenne.

CALYPTROCARYA GLOMERULATA Nees. *C. fragifera* Kunth. *C. angustifolia* Nees. (147). A low tufted sedge in damp forests. BRITISH GUIANA: Kamuni Creek, Groete Creek, Essequibo River, *22816*, *22848*; Kaieteur Savanna, *23250*. SURINAM: Saramacca trail, Jacob kondre, Saramacca River, *23838*; dakama forest, bottom Arrowhead Basin, Tafelberg, *24617*.

A variable species, represented in these collections by plants with leaves as much as 7 mm. wide (*23250*), and as narrow as 1.5 mm. (*24617*), the latter being representative of *C. angustifolia*. *C. intermedia* Clarke, noted by him as intermediate between *C. fragifera* and *C. Poeppigiana* and based partly on Im Thurn's collections from British Guiana, probably represents the broad-leaved phase of Maguire's collections. Below the achene is a disc, much as in *Scleria*, from the base of which several staminate spikelets radiate. Species of *Calyptrocarya* resemble *Bisboeckelera*, differing only in the non-fused scales which surround the achene. *C. glomerulata* is very common in the American tropics from British Honduras and Guatemala to Brazil.

CALYPTROCARYA POEPPIGIANA Kunth (147). SURINAM: frequent, secondary bush, Zanderij II, *23702*. Differs from *C. glomerulata* in broader leaves which are microscopically grayish pubescent, and in the larger achenes. Known from Peru and Colombia to northern Brazil.

LAGENOCARPUS AMAZONICUS (Clarke) Pfeiffer, Rep. Spec. Nov. **21**: 35. 1925. *Exochogyne amazonica* Clarke, Verh. Bot. Ver. Brand. **47**: 101. 1908. Tutin in Hook. Ic. **33**: *pl. 3273*. 1934. SURINAM: infrequent herb, with a single zigzag inflorescence at the culm apex, in small savanna northwest of Savanna VIII, Tafelberg, *24433*; rare in small rock savanna, low forest, northwest of Savanna VIII, Tafelberg, *24601*. The anthers are strongly fringed at the tip.

These collections were identified as *E. amazonica* by F. J. Hermann, who notes that the type specimen of *E. megalorryncha*, from the Potaro River, British Guiana, is "not nearly so pilose as Tutin described and figured" it (Hook. Ic. **33**: *pl. 3274*). *L. amazonicus* is said by Pfeiffer to be closest to the Brazilian *L. ciliatus* (Böck.) Pfeiffer, but it would seem to be perhaps

a much reduced *L. Kunthii*. *Exochogyne amazonica* was based on *Ule 6128* from the Marmellos River, a tributary of the Madeira; *E. decandra* Tutin came from Manaos (*Ule 8816*). *Exochogyne* has not been previously known from Surinam. The three described species are exceedingly close to one another, and probably not distinct.

LAGENOCARPUS KUNTHII (Miq.) Uittien. (132). *Cryptangium leptocladum* Böck. SURINAM: a slender species with filiform elongate panicles, south savannas, vicinity Arawak village of Mata, *24967*. Known also from the Amazon region of Brazil.

LAGENOCARPUS TREMULUS Nees (132). A tall (at least 1 m. high) coarse plant with culms as much as 1 cm. thick. BRITISH GUIANA: common, Kaieteur Savannas, *23465*. SURINAM: grass savanna, Zanderij II, *23660;* common, Savanna I, Tafelberg, *24221*.

Lagenocarpus is a difficult genus, mainly because very few collections have ripe fruit. Both *L. guianensis* and *L. tremulus* were based on collections made by Schomburgk in British Guiana, the latter species in a young stage without achenes. Uittien has separated the two on the basis of leaf width (15–35 mm. wide in *L. guianensis;* 6 mm. wide in *L. tremulus*) and on the character of the achenes. In *L. guianensis* the achenes are elongate-tapering, generally olive-gray in color; in *L. tremulus* they are shining brown, elliptic, and only 2 mm. long. The "perianth" of *Lagenocarpus* varies from a minute 3-lobed scale to three bristles which may be half the length of the achene. In the presence of a 3-lobed scale *Lagenocarpus* resembles *Scleria*. Except that the bristles in *Everardia* are finely divided, there semes to be but little difference between *Everardia* and *Lagenocarpus*.

CEPHALOCARPUS aff. RIGIDUS Gilly, Brittonia **3**: 152. 1939. Bull. Torrey Club **69**: 296, *f. 1*. 1942. BRITISH GUIANA: forming tussocks, branched or simple, rare, Kaieteur Savanna, *23453*. The leaves are 4–5 cm. long and 1.75 mm. wide; bracts 8–12 mm. long and conspicuously spreading-pubescent at base. The yellow to dark brown achene-body is 1.3–1.5 mm. long, 0.8–1.0 mm. wide, and the persistent (or tardily deciduous) beak sparsely pubescent, reddish-brown, becoming yellow in age. Hypogynous bristles, rising from a very low disc, are 0.6 mm. long. This collection does not fit well into Gilly's key because of the pubescent bract-sheaths, deciduous achene-beaks, and relatively narrow achenes. It has the general appearance of *C. longebracteatus* Gilly, but the pubescence is much as in the type of *C. rigidus* var. *mucronatus*. *C. rigidus* is known from the high plateaus of Venezuela.

DIDYMIANDRUM STELLATUM (Bock.) Gilly, Bull. Torrey Club **68**: 331, 1941. BRITISH GUIANA: tufted sedge to 2 m. high, leaves whorled, horizontal in three's, flower spikes erect, drooping at tip, Kaieteur Savannas, *23230* (staminate plant only). The species was collected originally by Schomburgk, probably during his visits to Roraima in 1838 and 1842, and was noted by Everard Im Thurm on his Mt. Roraima expedition in 1884. Böckeler called the plant *Cryptangium stellatum* in 1874. *Cryptangium* was placed under *Lagenocarpus* by both C. B. Clarke (1908) and Pfeiffer (1921), but *C. stellatum* was segregated out as a genus by Gilly chiefly on account of the dioecious character and the subverticillate arrangement of the leaves. Endemic to British Guiana.

EVERARDIA MONTANA Ridley. Perennial with a massive vertical rootstock, topped by a crown of narrow coriaceous leaves and several paniculate in-

florescences. SURINAM: frequent in wet places, Savanna IV, Tafelberg, *24382;* infrequent, moist rocky places, base of west escarpment, Tafelberg, *24679.*

Both collections agree well with the original description and plate, though Ridley quite evidently had immature and insufficient material for delineation of the pistillate spikes. Especially in *24382,* the upper portion of the inflorescence is predominantly staminate and does not conform to Gilly's characterization of *Everardia* (Bull. Torrey Club **68**) as having the "upper portion of the inflorescence wholly pistillate or rarely with a few staminate spikelets—accompanying the pistillate." Character of sheaths and disposition of the inflorescence branches coincide with the situation in *Lagenocarpus.*

From *Cephalocarpus* Maguire's collections are not readily separated. The achenes have a shrinking of the neck in age that would place them in *Cephalocarpus.* The hypogynous cup formed by fusion of three small scales in *Cephalocarpus,* as in *Everardia,* can also be readily seen in *Lagenocarpus,* except that the scales are not fringed. *Maguire 23482* has within itself the characteristics of *Everardia, Cephalocarpus,* and *Lagenocarpus.* Perhaps Pfeiffer was correct in placing the small genus *Cephalocarpus* within *Lagenocarpus.*

PALMAE[21]

The large proportion of novelties in this small palm collection well illustrates the need for continued botanical exploration of the hinterlands of the Guianas—Venezuelan, British, Dutch, French, Brazilian.

BACTRIS sp. SURINAM: frequent, stems 3–5 m. high, savanna bush, Savanna VIII, Tafelberg, *24461.* No fruit and therefore cannot be identified. Very close to *B. savannarum* Britt. but probably not the same.

HYOSPATHE sp. SURINAM: frequent, canes 2 m., leaves cut, inflorescence red, mostly hillsides in forest, and borders of swamps, sometimes in swamps, vicinity Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, *24116;* locally common, leaves cut, swamps, km. 14, line between Kwatta and Pakira Camps (3 and 4), Coppenam River Headwaters, *24155.* No fruit. Perhaps related to *H. elegans* Mart. of Brazil.

GEONOMA ACAULIS (Poit.) Burret. SURINAM: frequent, without cane, stem short, leaves near base, blades cut, inflorescence a spike, unbranched, enlarged, fruit black, forest and borders of swamps, vicinity Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, *24117.* French Guiana.

Geonoma Maguirei Bailey, sp. nov. (Fig. 5.) Humilis, gracilis, 5 dm. alta, glabra, inermis; folia parva, densa, simplicia, 16–18 cm. longa, 6–8 cm. lata, a latere multinervata ex costa media, angustata ad basin, bilobata apice, lobi 4–5 cm. longi, divaricati et valde acuti; inflorescentia erecta in axillis petiolorum lata basi, axes simplices et 2–3 cm. longi, spatha invisa; flores unici vel aliquid aggregati, dentati apice; fructus latoconici, circa 1 cm. longi, caeruleo-nigri.

Long very slender stem below the crowded crown of foliage, 5 dm. tall, glabrous, unarmed; leaves small, crowded, simple, 16–18 cm. long, 6–8 cm. broad, laterally many-nerved from midrib, narrowed to base, bilobed at apex, lobes 4–5 cm. long, divaricate and very acute; inflorescence erect in axils of

[21] By L. H. Bailey.

broad-based petioles, axes simple and 2–3 cm. long, spathes unknown; flowers single or somewhat aggregated, dentate at apex; fruit broad-conic, about 1 cm. long, blue-black.

FIG. 5. *Geonoma Maguirei* Bailey. *Maguire 24166.* × ½.

TYPE: infrequent, slender cane, 5 dm. tall, fruit blue-black, low forest, line beyond Pakira Camp (4), Coppenam River Headwaters, Surinam, July 24, 1944, *Maguire 24166.* New York Botanical Garden.

This plant differs from *Geonoma stricta* in its smaller less rigid stature, thinner and less nodose caudex, relatively shorter and broader leaves, and petiole bases not strigose.

GEONOMA BACULIFERA (Poit.) Kunth. SURINAM: abundant, stem to 2 m. high, leaves terminal at summit of cane, dominant in pine forest and swamps, Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, *24094;* locally abundant, caned leaves not cut, swamps along km. 14, between Kwatta and Pakira Camps (3 and 4), Coppenam River Headwaters, *24154.* French, Dutch, and British Guiana, Venezuela.

GEONOMA affin. *G.* VAGA Griseb. & Wendl. BRITISH GUIANA: frequent, banks and swamps along Kamuni Creek, Groete Creek, Essequibo River, *22939.* It will require much more material (including fully mature fruit) before the merits of *G. vaga, G. pinnatifrons,* and *G. binervia* can be made out.

Geonoma saramaccana Bailey, sp. nov. (Fig. 6.) Humilis, caulis brevis non arboreus, inermis, glaber; folia simplicia vel fortasse scissa ad basin, paene vel admodum .5 m. longa et 12–14 cm. lata, bilobata apice circa 15 cm. profunda, lobi acutissimi, fastigati ad basin, nervi laterales multi validique; inflorescentia erecto-divaricata ex axillis, pedunculus teres et 16–20 cm. longus, rami 3 vel 4, 15–18 cm. longi, spathae non evidentes; flores parce inserti, 5–10 mm. inter se; fructus globulares, nigri, 6–7 mm. diam.

Low palm with leaves all basal, perhaps not exceeding 1 m. in height, not arboreous, unarmed, glabrous; leaves simple or perhaps split toward base, nearly or quite .5 m. long and 12–14 cm. broad, bilobed at apex about 15 cm. deep, lobes very acute, tapering to base, lateral veins many and strong; inflorescence erect-divaricate from axils, peduncle terete and 16–20 cm. long, branches 3 or 4, 15–18 cm. long, spathes not evident; flowers scarcely imbedded, 5–10 mm. asunder; fruit globular, black, 6–7 mm. diam.

TYPE: infrequent, leaves basal, stem short, in swamp, Base Camp (1), Tafelberg Creek, Saramacca River Headwaters, Surinam, July 9, 1944, *Maguire 24095.* New York Botanical Garden.

YUYBA, Bailey, Gent. Herb. **7**: 413. 1947. *Amylocarpus* Barb.-Rodr. Contrib. Jard. Bot. Rio de Janeiro, **3**: 69 (1902), non Currey, 1857. This is a new generic name to replace *Amylocarpus* of Barbosa Rodrigues, a name disqualified by the fungus *Amylocarpus* of Currey (1857), as stated by Drude in Engler & Prantl, *Pflanzenfamilien,* Nachtrag **3**: 28; Drude states that *Amylocarpus* Barb.-Rodr. must be displaced but does not propose a new generic name. Since Drude's time the genus has been merged in *Bactris,* with confusion. I have long held the genus to be distinct and with sound characters of separation, but have not written on these palms until recently.

Barbosa divides his genus *Amylocarpus* into two sections, *Marayarana* and *Yuyba,* which latter in English I pronounce "Yuee-ba." The first-section includes palms with bifid or furcate leaves and the second those with leaves more or less pinnatisect or pinnate. They are all little understory palms, some of them devoid of prickles or pricklets, heretofore recognized as Brazilian.

Barbosa does not indicate a type for his genus *Amylocarpus.* In my treatment of the genus, under the name *Yuyba,* I assume *Bactris simplicifrons* of Martius as typical. The genus appears not to be homogeneous, and as material accumulates we may be under the necessity of dividing it.

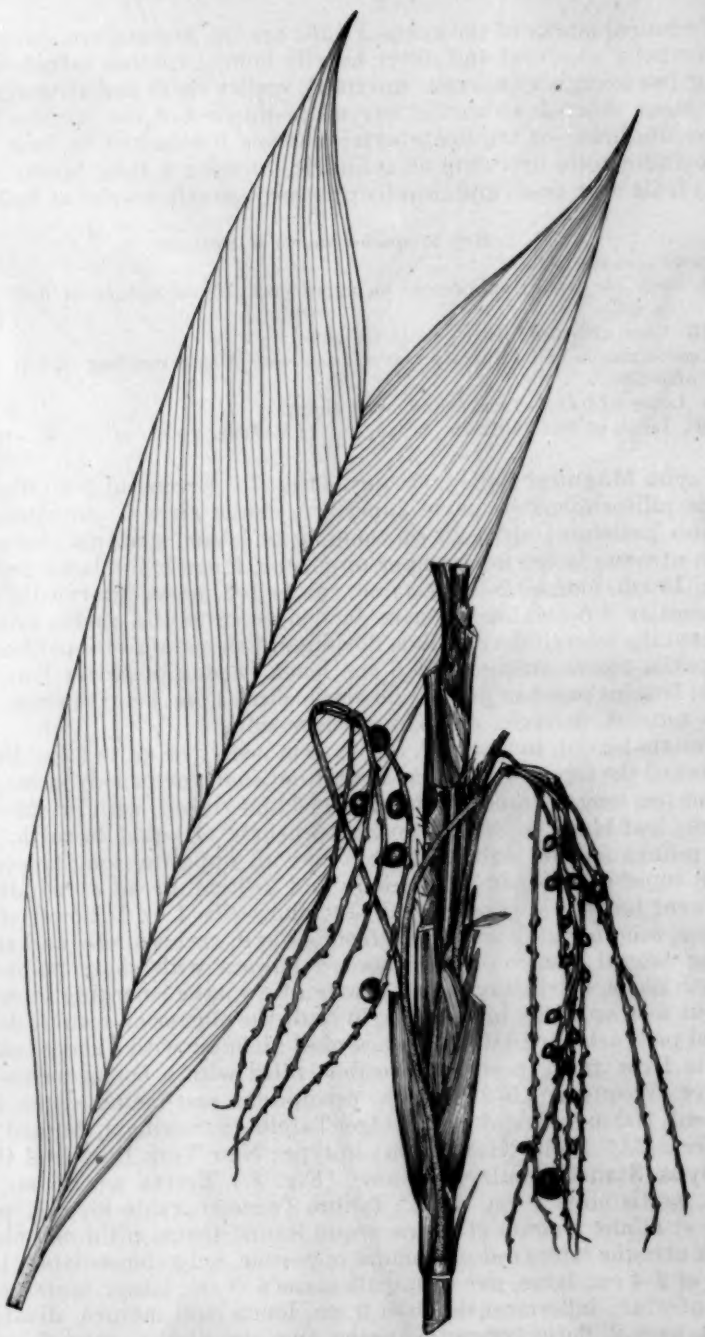


FIG. 6. *Geonoma saramaccana* Bailey. *Maguire 24095.* × ⅛

Technical marks of the genus *Yuyba* are the low stature, parts all small, often wholly unarmed and never heavily spiny; spathes infrafoliar, only 9 cm. or less long, very narrow, unarmed, spadix short and strongly decurved on a stout short downwardly curved peduncle 6–8 cm. or less long, of a single, duplicate or triplicate axis; stamens 6 attached to base of petals; calyx and corolla urceolate or cylindric, forming a tube briefly dentate at apex; fruit very small and usually unarmed, mostly scarlet at full maturity.

Key to species known in Surinam

A. Leaves pinnate.
  B. Stem (or trunk) spiniferous on upper part; leaves opaque or dull in color. *Y. Maguirei.*
  BB. Stem unarmed; leaves distinctly glossy. *Y. Stahelii.*
AA. Leaves simple and bifurcate; bifurcation very deep, extending to top of petiole.
  B. Lobes of leaf 7–8 cm. broad, very glossy. *Y. dakamana.*
  BB. Lobes of leaf 10–12 cm. broad, dull in texture. *Y. essequiboensis.*

Yuyba Maguirei Bailey, sp. nov. (Fig. 7.) Erecta ad 2 m., tantummodo aculeis piliformibus in parte superiore, caulis circa 1 cm. diam.; folium (praeter petiolum) circa 20 cm. longum et latum, glabrum, tenue; pinnae 5–7 in utroque latere non semper oppositae, longo-lanceolatae gracile apice curvo, 18 cm. longae, 2–3 cm. latae, costae 1–3, nervi intermedii pauci; inflorescentiae 3–6 cm. longae, mox pendentes, in axillis, rachis unica et simplex ramulis lateralibus brevibus floribus spissis petalis et sepalibus attenuatis; spatha postea emergens, 4–5 cm. longa et mox in partes longitudinales divisa; fructus pauci in pedunculo curvo, circa 1 cm. longi et crassi, rostrati; semen unicum, solidum, albumen homogeneum.

Pinnate-leaved, to 2 m. tall, erect; stem nearly or quite 1 cm. thick, bearing toward the top a few very weak soft not sharp or prickly spine-like hairs 2 cm. or less long; petiole slender, 2-edged and ribbed, with prickle-like hairs at base; leaf-blade to 30 cm. long and nearly of equal breadth, glabrous, thin; pinnae 5–7 on either side but not all opposite, long-lanceolate and curved taper-pointed, to 18 cm. long and 2–3 cm. broad at middle, midrib prominent but not always central, secondary ribs 1 or 2; flower-cluster 3–6 cm. long, soon hanging, emerging from an axil, rachis single and simple but bearing lateral branchlets of crowded flowers with sharp-pointed chaffy perianth parts, producing only a few fruits; spathe emerging later, 4–5 cm. long but soon splitting into shreds, in fruit the cluster on a stout downward-crooked peduncle; fruit drupe-like, almost globular with a short beak, nearly or quite 1 cm. thick in either direction, filled with a homogeneous seed.

TYPE: frequent, 1.5–2 m. high, precipitous east-facing slopes above escarpment, 300 m. south of East Ridge, Tafelberg, Surinam, August 29, 1944, *Maguire 24555*. Bailey Hortorium; isotype: New York Botanical Garden.

Yuyba Stahelii Bailey, sp. nov. (Fig. 8.) Erecta ad 1.5 m., inermis, glabra, caulis circa 1 cm. diam.; folium (praeter valde longum petiolum) 30 cm. et minus longum et paene aeque latum, tenue, nitidum; pinnae 3–4 vel 5 in utroque latere sed non omnes oppositae, longo-lanceolatae, 18–20 cm. longae et 2–4 cm. latae, par terminale saepe 6–8 cm. latum, costae paucae et non confertae; inflorescentia circa 3 cm. longa cum matura, divaricata vel deflexa, axes 2, flores congesti; spatha angusta, glabra, circa 5 cm. longa; fructus multi et spissi, circa 5 cm. longi (immaturi) et rostrati.

FIG. 7. *Yuyba Maguirei* Bailey. *Maguire 24555.* × ½.

Pinnate-leaved, erect, 1–1.5 m. tall, unarmed, stem about 1 cm. thick; petiole very long and slender, often 30 cm. and more, ridged; leaf-blade 30 cm. and less long, thin, glossy; pinnae 3–4 or 5 on either side but not all opposite, long-lanceolate with curved slender point, 18–20 cm. long, 2–4 cm. broad at middle but the terminal pair often 6–8 cm. broad, main ribs 1–several; clusters about 3 cm. long at maturity, divaricate or down-curved in fruit, flowers in dense little clumps, main axes 2, emerging narrow glabrous spathe eventually about 5 cm. long and declined; fruit freely produced, pointed, about 5 mm. long but not yet mature.

TYPE: in coastal region, Zanderij, Surinam, *Dr. Gerold Stahel*, sine no. Bailey Hortorium; isotype: New York Botanical Garden.

Yuyba dakamana Bailey, sp. nov. (Fig. 9.) Valde gracilis, fortasse 1 m. alta, debiliter aculeata in parte superiore et petiolis, caulis minus quam 1 cm. diam.; folium tenue, nitidum, profunde bifurcatum, folia inferiore tota, lobi terminales circa 30 cm. longi et 7–8 cm. lati, 7-nervati, apex acutus, petiolus ad 18 cm. longus, porriginosus et spinescens; inflorescentia deflexa, axis unicus circa 6 cm. longus, pedunculus validus curvusque, spatha ad 9 cm. longa et 1 cm. lata, acuta; flores unici et non aggregati, tubulares, dentati apice; fructus invisi.

Very slender, weakly prickly on upper part and petioles, perhaps 1 m. tall, stem less than 1 cm. thick; leaf thin, bifurcate or the lower ones entire, glabrous, shining, each of the 2 lobes nearly or about 30 cm. long, 7–8 cm. broad, strongly about 7-nerved, apex acute, petiole to 18 cm. long, scurfy and spinescent; inflorescence pendent from a stout curved peduncle, axis single about 6 cm. long, spathe to 9 cm. long and 1 cm. broad and acute; flowers single, tubular, dentate at apex; fruit unseen.

TYPE: in dakama bush at bottom of Arrowhead Basin, Tafelberg, Surinam, September 3, 1944, *Maguire 24614*. Bailey Hortorium; isotype: New York Botanical Garden.

Yuyba essequiboensis Bailey, sp. nov. (Fig. 10.) Erecta ad 1.5 m. alta, glabra, inermis, caulis 1 cm. vel plus diam.; petiolus 12–15 cm. longus, costatus; folium (praeter petiolum) 30 cm. vel plus latum et paene aeque longum, 2 lobis terminalibus, costae maximae 7 vel 8 nervis tenuibus inter eas, brevius acutae; spatha divaricata vel deflexa, straminea, 5–6 cm. longa, circa 1 cm. lata, acuminata; axis spadicis unicus, pedunculus validus curvusque; flores unici, tubulares, dentati apice; fructus invisi.

Bifurcate-leaved, to 1.5 m. tall, glabrous, unarmed, stem with sheaths 1 cm. or more thick; petiole relatively short, to 12–15 cm. long, ribbed; leaf-blade large, thickish, or 2 broad diverging lobes each about 30 cm. long and 10 cm. broad, with 7 or 8 main lengthwise ribs and fine veins between, apex running to a brief point; spathe 5–6 cm. long, tawny when dry and glabrous, about 1 cm. broad and pointed, divaricate or becoming deflexed; axis of spadix single, soon pendent with stout curved peduncle; flowers single rather than bunched, tubular, dentate at apex, stramineous; fruit not seen.

TYPE: infrequent, to 1.5 m. high, swampy area, in mora and mixed forest, Kamuni Creek, Groete Creek, Essequibo River, British Guiana, April 14, 1944, *Maguire & Fanshawe 22835*. New York Botanical Garden.

Desmoncus Maguirei Bailey, sp. nov. (Fig. 11.) Scandens circa 4 paribus retrorsonum uncorum rigidorum 3 cm. vel plus longorum; caules vaginaeque circumdata aculeis bulbosis 15 mm. vel minus longis; folia 15 dm.

FIG. 8. *Yuyba Stahelii* Bailey. *Dr. Gerold Stahel*, coastal region, Zanderij, Surinam, sine no. × $\frac{1}{3}$.

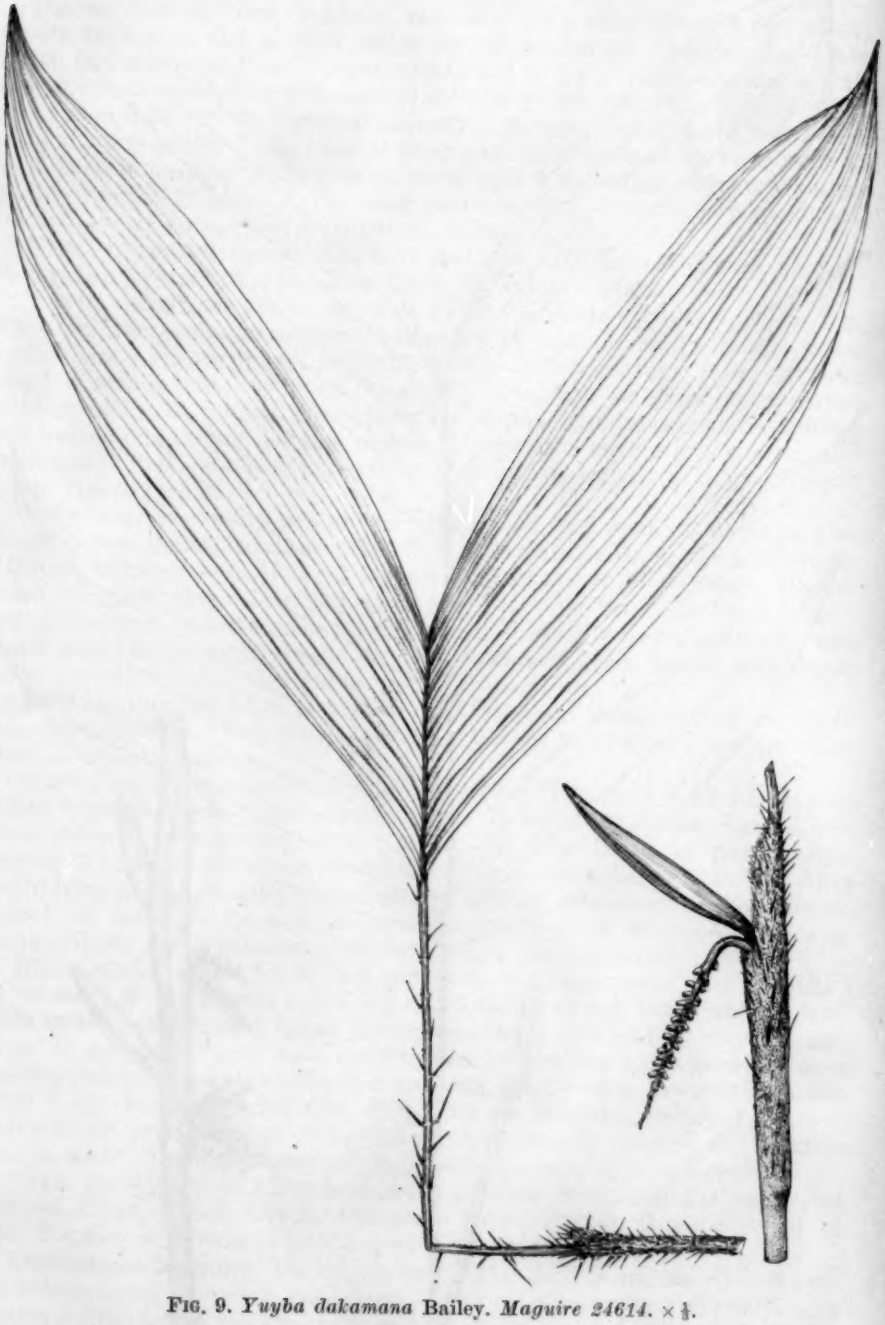


FIG. 9. *Yuyba dakamana* Bailey. *Maguire 24614.* × ¼.

vel plus longa, pinnata; pinnae non omnes oppositae, angustae, longo-acuminatae, ad 15 cm. longae, 3–4 cm. latae, inermes praeter ad basin, rachis

FIG. 10. *Yuba essequiboensis* Bailey. *Maguire & Fanshawe 22835.* × ½.

armata uncis brevissimus; spatha cylindracea, 25 cm. vel plus longa, 15 mm. crassa, brunneus, bulbosis uncis declinatis consita 5 mm. vel minus longis.

FIG. 11. *Desmoncus Maguirei* Bailey. *Maguire & Stahel 25011.* × ⅓.

FIG. 12. *Desmoncus kaieteurensis* Bailey. *Maguire & Fanshawe 23093.* × ⅓

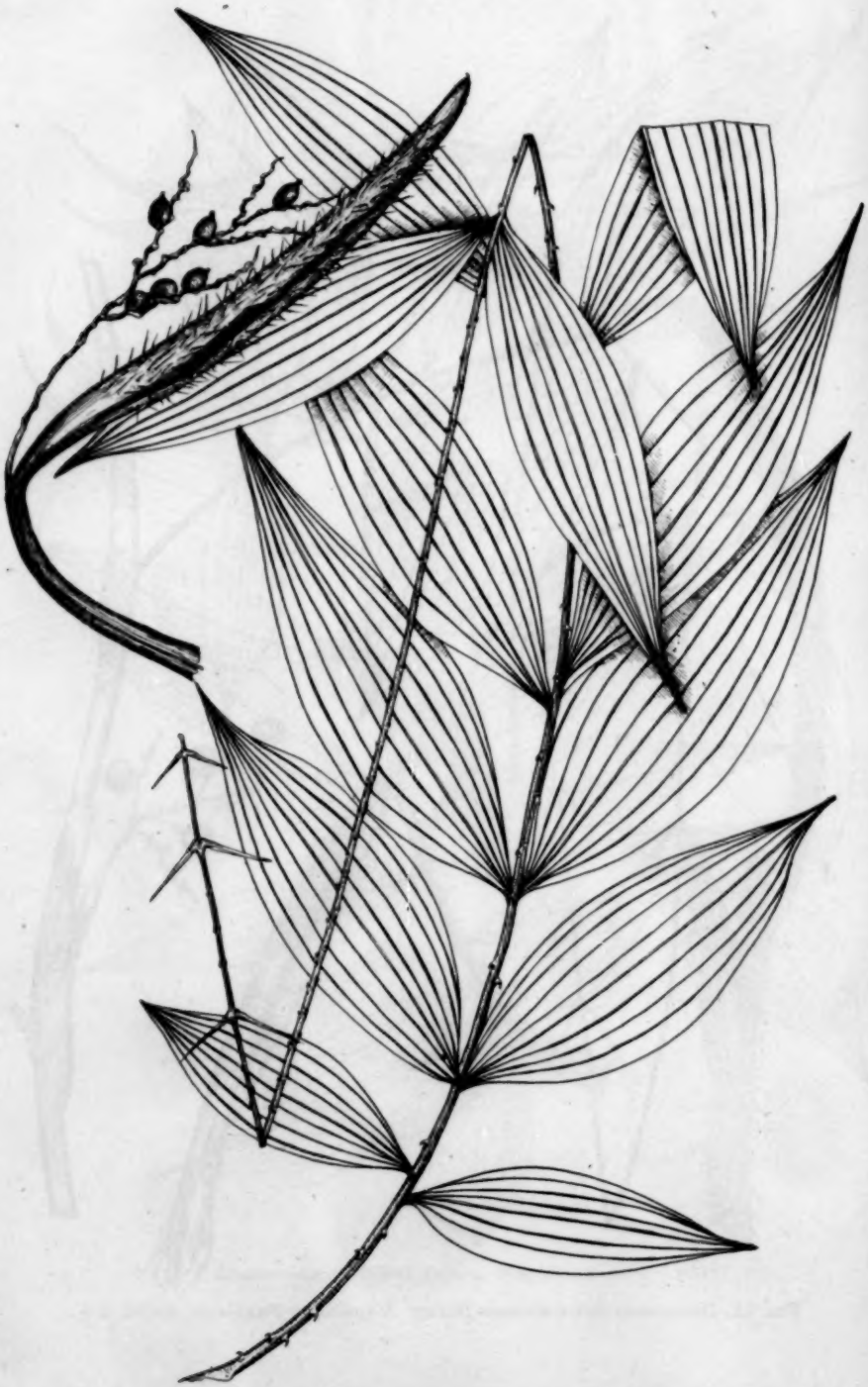


FIG. 13. *Desmoncus parvulus* Bailey. *Gleason 164.* × ⅓.

Climber with about 4 pairs of retrorse stiff hooks 3 cm. or more long; stem and sheaths beset with bulbose prickles 15 mm. and less long; leaves 15 dm. or more long, pinnate; pinnae not all opposite, narrow, long-acuminate, to 15 cm. long, 3–4 cm. broad, unarmed except near base, rachis armed with very short hooks; spathe cylindric, 25 cm. and more long, 15 mm. thick, brown, covered with bulbose declined hooks 5 mm. and less long.

TYPE: in second-growth jungle known to natives as "bamba maka," Kwakoegron, Surinam, October 19, 1944, *Maguire & Stahel 25011.* Bailey Hortorium; isotype: New York Botanical Garden.

Desmoncus kaieteurensis Bailey, sp. nov. (Fig. 12.) Scandens; folia pinnati, uncorum pauca paria, gracilia, 3 cm. vel minus longa, rachis multis uncis minimus 1 mm. vel plus longis; pinnae non omnes oppositae, lato-ellipticae, breviter sed conspicue acuminatae, angustae basi, inermes, 15 cm. vel minus longae, 5 cm. latae; inflorescentia brevis, simpliciter ramosa, 7–8 cm. longa; spatha cylindracea, 9–10 cm. longa, multis pilis bulbosis mollibusque 3 cm. vel minus longis; fructus rufi, globosi, circa 1 cm. diam.

Climber; leaves about 7 dm. long, pinnate, hooks a few pairs, slender, 3 cm. or less long, rachis with many very small hooks 1 mm. and more long; pinnae not all opposite, broad-elliptic, briefly but conspicuously pointed, narrow at base, unarmed, 15 cm. or less long, 5 cm. broad; inflorescence short, simply branched, 7–8 cm. long; spathe cylindric, 9–10 cm. long, with many bulbose soft hairs 3 cm. or less long; fruit red, globose, about 1 cm. diam.

TYPE: locally frequent, climbing palm, midrib continued above leaflets, hooked and barbed, fruit globose, red, secondary forest, trail from Tukeit to Kaiatuk Plateau, British Guiana, April 29, 1944, *Maguire & Fanshawe 23093.* Bailey Hortorium; isotype: New York Botanical Garden.

Desmoncus parvulus Bailey, sp. nov. (Fig. 13.) Probabiliter parva et gracilis; pinnae 6–8 paribus, paene vel admodum oppositae, breves lataeque, 15–20 cm. longae, 3–5 cm. latae, breviter acutae ad apicem basinque, sine spinis; petiolus rachisque paucis parvis spinis curvis 1–3 mm. longis, uncis parvi debilesque, 2 cm. vel minus longi; spatha parva angustaque, cylindracea, spinis brevibus basi crassa; fructus oblongo-acuminati, circa 15 mm. longi.

Probably small and slender; pinnae 6–8 pairs, nearly or quite opposite, short and broad, 15–20 cm. long, 3–5 cm. wide, briefly acute to apex and base, spineless; petiole and rachis with few small curved spines 1–3 mm. long, hooks small and weak, 2 cm. or less long; spathe small and narrow, cylindric, covered with thick-based short spines; fruit oblong-pointed, about 15 mm. long.

TYPE: in dense upland forest, Tumatumari British Guiana, *Gleason 164.* New York Botanical Garden.

The species is apparently close to *D. kaieteurensis,* but leaflets are much narrower and long-acuminate, more strongly nerved, hooks more divaricate, spathe with stouter armature, fruits (immature) elongate rather than globular.

Gen. et sp. indet. SURINAM: frequent, low-growing, 1 m. high, in low forest, vicinity Black Water Camp (5), Coppenam River Headwaters, *24178.* Probably a new genus, but no flowers, no filled-out fruits.

BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 75, NO. 1, PP. 116–120 JANUARY, 1948

TORREYA

Measurements of the Annual Growth-Rate of Two Species of Rock Lichens. During the years 1939 to 1947, on or about the first of July of each year, my husband and I made measurements of the annual growth-rate of two species of rock lichens, one growing on the upper slopes and the other near the summit of Mt. Monadnock, in the southern part of New Hampshire. The first species was the ring lichen (*Parmelia centrifuga*); and the second was the green map lichen (*Rhizocarpon geographicum*).

Parmelia centrifuga was represented by three isolated plants growing on an exposed ledge of mica schist on the southwest slope of the mountain at an elevation of about 2,170 feet. The plants were shaded during the first half of the day by a clump of red spruce, but exposed to the full sunlight during the last half of the day. At this elevation there is found, growing together with *Parmelia centrifuga*, a closely allied species, *P. conspersa*. The three plants of *P. centrifuga* were measured with a steel millimeter rule, laid along the major axis of each plant, between small drill holes in the rock, thus insuring that the annual measurements were made along exactly the same lines. The measurements were made on the first, or during the first week, of July each year.

TABLE 1. *Annual growth of lichens in millimeters.*

Parmelia centrifuga	Diameter in 1939 in mm.	1939 to 1940	1940 to 1941	1941 to 1942	1942 to 1943	1943 to 1944	1944 to 1945	1945 to 1946
Plant No. 1	11.0	0	1.5	2.5	0	1.0	1.0	1.5
Plant No. 2	5.0	1.0	0.5	2.0	1.0	0.5	1.0	0.5
Plant No. 3	16.0	1.0	0	1.0	0	1.0	0.5	0.5
Rhizocarpon geographicum	in 1942 31.0	....	....	....	1.0	0.55	0.6	0.75

The single plant of the green map lichen (*Rhizocarpon geographicum*) was similarly measured some time during the first two weeks of each July from 1942 to 1946, giving four year-periods. This plant grew on an exposed ledge of rock of extremely firm and compact mica schist (more like a grayish quartzite) at an elevation of 3,010 feet, near the summit of the mountain, entirely open at all times of day to the sun, and with a steep south slope. The record of the measurements of all four plants is given in table 1.

The average annual growth of the three plants of *Parmelia centrifuga* over a seven-year period was 0.85 mm. and that of the one plant of *Rhizocarpon geographicum* over a four-year period was 0.72 mm. It will be noted from the table that there was more growth of two of the plants of *Parmelia centrifuga* in 1941–42 than in any other year for which measurements were made. The growth of the third plant was as great as that in any year, and greater than most of the measurements.

This may have been because the mountain was (or seemed to be, without the backing of any precise data on the subject) more swathed in clouds than in other summers. I remember that there were many days in succession when climbers were "house-bound" because of the dense cloud on the mountain.

The three plants of *Parmelia centrifuga* grew where they were partially shaded a good deal of the day; the temperature of the surface of the rock whereon they grew never exceeded (by our records) about 115° F. Being partly sheltered by spruce prevented them from drying out for long periods of time. Nor were they, in their protected situation, blown over by cold winter winds, nor left exposed during the entire winter without a blanket of snow or ice.

The plant of *Rhizocarpon geographicum*, however, was exposed to the sun at all times; the temperature of the adjacent rock-surface measured (on one occasion) 144° F.—hotter than the hand could bear with any comfort. This must be a common condition. The plant at this time (or one nearby) seemed as dry as powder. During the winter no snow could accumulate on the steep, smooth, rock surface on which the plant grew. It was therefore exposed to temperatures far below zero. (At our farm-house, 9 miles distant, winter temperatures of −46° F. were common). These extremes of heat and cold and of desiccation, meant that there were periods, perhaps long ones, when the plant existed statically, without growth.

The largest plant of *Rhizocarpon geographicum* which we found on this mountain (3,166 ft. altitude), also fully exposed, measured about 86 mm. in diameter. Supposing the rate of growth of such plants to be roughly the same in the same situations, we computed the age of this plant to be about 120 years. If lichens of this same general nature (as *Parmelia centrifuga, P. conspersa, Rhizocarpon geographicum,* and *Lecidea cyanea*) increase in diameter in the order of magnitude suggested by these records, then some much larger ones, in higher mountains where the growth-rate must be much more retarded, must be thousands of years in age. In old plants the central tissues of the disc (the first ones) have disappeared, leaving only a large ring of growing tissue.

Studies of the growth of some of the lichen-patches on Mt. Washington, and on the higher mountains of the West, would be most interesting.—Ethel Hinckley Hausman.

Reviews

North American Species of Mycena. By Alexander H. Smith. i–xviii, 1–521. *f. 1–56, pl. 1–99.* Ann Arbor: University of Michigan Press; London: Geoffrey Cumberlege, Oxford University Press. 1947.

It is needless to say that original taxonomic monographs based on a broad approach, not excluding comparative cytology, anatomy, chemical characters and ecology of the organisms studied, are presently the most urgently needed contributions in the field of cryptogamic botany. Smith's *Mycena* book is, in spite of its modest title, a monograph of this sort and will be invaluable to American as well as foreign mycologists. The reviewer no less than others who have been endeavoring in similar original studies can appreciate the immense amount of work that has been necessary to assemble and reassemble the innumerable facts presented in the 232 complete de-

scriptions, the notes on various other species, the 56 anatomical figures and the 99 plates reproducing the author's photographs of fresh material. The author has, in earlier papers, pioneered in the cytological study of the genus Mycena, and has now introduced into his descriptions a very careful study of the anatomy of the various parts of the carpophores and the iodine reaction of the spore walls and tissues. His keys are very clear and can be used advantageously by discriminating, trained students.

Some taxonomists might be inclined to criticize Smith's extremely broad concept of the genus *Mycena*, a concept much broader than that of Fries and the classical school, but nearly coinciding with that of the author of a previous monograph, R. Kühner. However, in the reviewer's opinion this broad concept is a progress rather than a regress since both these monographers have noticed the affinities of the various groups combined in *Mycena sensu* Fries with species formerly dispersed all over the Agaricales, whereby it appeared impossible to separate these species generically from elements now usually considered as true Mycenas. The only alternative would have been the partition of the genus, *i.e.* the admission of several smaller genera instead of a single one, a solution which the author was not quite ready to adopt. Some remarks in the book lead one to assume that the author's aim was a monograph of the species referable to the *facies* Mycena rather than to the systematic-nomenclatural unit Mycena. If the reviewer has understood this attitude correctly, he is inclined to believe that Smith's conception of *Mycena* was proper in view of the personal interpretation he gave to his problem.

Another point that might perhaps be criticized is the minimizing of the microchemical characters,—in this case in vivid contrast to the views of the author's predecessor, Kühner, whose classification is mainly based on differences in the iodine reaction and metachromatism in cresyl blue stains. While admitting that the iodine reaction is a character of major importance, Smith goes on the declare "I have minimized its use . . . because of the difficulty of determining it on fresh material. It is a character of considerable value to the specialist, but one likely to be difficult for the beginner to interpret." While this point of view may be reasonable or at least defendable, the reviewer fails to see why it should have influenced questions of taxonomy and affinity. In fact, it cannot be denied that certain sections such as the *Deminutivae*, are based on rather weak characters, and would naturally fall apart if treated with less respect for the fallacies of the beginner. On the other hand, it must be recognized that the inclusion of certain species with unknown iodine reaction [e.gr. *Mycena minutula* (Peck) Sacc.] seems to be desirable for reasons of floristic completeness, and an emphasis on microchemical reactions would have made their inclusion impossible.

It would be unreasonable to expect that in the course of admitting or rejecting some 500 binomials, the author should have always decided in favor of a name acceptable to *all* other mycologists. This is not the fault of any specialist but of the state of botanical nomenclature whose rules are at present not quite explicit enough to eliminate personal preferences of the monographer. For instance, the reviewer would have preferred the proposal of a few *nomina nova* to somewhat precarious interpretations of European species, especially those not proved to occur in both continents. However, the author has never disregarded the International Rules, an attitude that

tends to make his nomenclature less vulnerable to future readjustments than that of many other contemporary authors.

The book contains a definition of the genus *Mycena*, a short history of past research on *Mycena* in North America, a valuable discussion of all diagnostic characters, a review of the accepted classification (the author divides *Mycena* into 17 sections and a number of subsections and *stirpes* which are grouped within the 4 main subgenera: *Pseudomycena, Eumycena, Glutinipes* and *Mycenella*), and a complete taxonomic treatment of the temperate and some subtropical species. The majority of the tropical and subtropical and also all the excluded and doubtful species are treated in supplements which contain very interesting information on type material. The use of the *stirps* as a taxonomic entity reuniting a group of obviously closely related species has been adopted from the French mycologists. Its use in fungus-monographs, especially of large genera, has definite theoretical and practical advantages.

The illustrations are plentiful and, as always in Smith's papers, excellent.—ROLF SINGER.

Origins of the Flora of California. By Douglas H. Campbell and Ira L. Wiggins. Stanford University Publications, University Series, Biological Sciences **10**: 3–20. 1947.

The fact that "California is unique in its almost complete phytogeographic isolation" is attributed by the authors not primarily to the felicitous climate (!) but to the events of geological history which have effectively separated the area from the rest of the United States since Cretaceous time. The unusual diversity in climate (temperature, quantity and seasonal distribution of rainfall) and topographic relief have, of course, contributed markedly to the present multiplicity of species. Even by conservative estimates the number of species and varieties in the area exceeds that included in the seventh edition of *Gray's Manual*, and has been estimated to approach five thousand. There thus appears to be justification in concluding that this is "a separate botanical province, comparable with such areas as the Iberian Peninsula, certain other Mediterranean regions, the Cape region of South Africa, or Western Australia." With migration from the east barred since the Cretaceous by a cordilleran and climatic Iron Curtain, the various components of the flora are believed to have entered their present stations principally from the north (circumboreal, eastern American, and Asiatic elements) and from the south (Mexican, Central American, and temperate South American types) by way of the Coast Ranges and the Sierra Nevada.

Some thirty-six percent of the species and varieties inhabiting California are construed as endemic, and the old dichotomy of "relictual" versus "beginning" species is reintroduced. No mention is made of Mason's effective correlation of a considerable sector of the endemics with edaphic factors (*Madroño* **8**: 209–226, 241–257. 1946), the case of the serpentinophiles in the area being one of the most striking. Of the genera listed as being particularly rich in local species in California, it is difficult to know how much of the endemism to attribute to the plants, and how much to the taxonomists. The conclusion that the majority of the endemics have originated in their present area has much to recommend it, including common sense.

Campbell and Wiggins, although introducing few new concepts or explanations,

have written a concise and highly readable account of the development of the present flora of California, which will enable the outlander to understand better the problems confronting Pacific Coast botanists, and may give needed orientation even to workers within that area.—LINCOLN CONSTANCE.

NEWS NOTES

Last year the Board of Regents of the University of Minnesota accepted a gift of $15,000 to establish "The Conway MacMillan Memorial Research Fellowship in Botany, Charles J. Brand, 1902, Founder," with an annual stipend of $1,200. Mr. Brand plans to add to the fund, and hopes to interest other men and women who were trained by Professor MacMillan in making the fellowship permanent. Professor MacMillan was head of the Department of Botany at the University of Minnesota from 1891 to 1906. During that time he published a number of books on Minnesota plants and initiated a series of studies on different groups of Minnesota plants which were carried out and published by his students. To be eligible for this fellowship a student must be a doctoral candidate at the University of Minnesota and have a master's degree.

The Save-the-Redwoods League is launching a campaign for membership and increased public participation in its program. According to the new annual report of the League, "All the world hails the majesty and grandeur of the primeval forests of Sequoia sempervirens. It comes as a shock to many to realize that unless the program of the Save-the-Redwoods League is fully successful some of the finest of these Redwood forests are in danger of being destroyed, for they are in the path of lumbering operations." The Treasurer, to whom contributions to the Save-the-Redwoods League may be sent, is Dr. Robert Gordon Sproul, 250 Administration Building, University of California, Berkeley 4, California.

The Editor announces that a new *Memoir* of the Torrey Botanical Club, Vol. 20, No. 2, will be published early in 1948. It is by Robert L. Lowry (Michigan State College), "A Cytotaxonomic Study of the Genus *Mnium*." It will contain taxonomic descriptions of the species of *Mnium*, an account of their chromosomes, and a discussion of their relationships. About 50 pages. Illustrated. Price $1.50.

INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITOR OF THE TAXONOMIC INDEX

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used to include the entire Western Hemisphere.

Papers that relate exclusively to bacteriology, forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included. If users of the Index will call the attention of the Bibliographer to errors or omissions, their kindness will be appreciated.

The Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of three cents for each card. The different subjects as classified below may be ordered separately (but no orders will be taken for less than one year's issue in any classification). Correspondence relating to the card issue should be addressed to the Treasurer of the Club.

TAXONOMY, PHYLOGENY AND FLORISTICS

ALGAE

Abbott, Isabella A. Brackish-water algae from the Hawaiian Islands. Pacif. Sci. **1**: 193–214. *f. 1–13.* O 1947.

Brunel, Jules. *Vaucheria Schleicheri* in North America. Contr. Gray Herb. **165**: 62–69. *f. 1, 2 + table 1.* 6 O 1947.

Dawson, E. Yale. A guide to the literature and distributions of the marine algae of the Pacific Coast of North America. Mem. So. Cal. Acad. **3**: 1–134. 1946 [Ja 1947].

Dawson, E. Yale. Lista de las algas marinas de la costa pacífica de Mexico. Revista Soc. Mex. Hist. Nat. **7**: 167–215. D 1946.

Fritsch, F. E. The structure and reproduction of the algae. II. [Phaeophyceae, Rhodophyceae, Myxophyceae]. *i–xiv*, 1–939. *front., f. 1–336, 2 maps.* Cambridge. 1945.

Papenfuss, George F. Extension of the brown algal order Dictyosiphonales to include the Punctariales. Bull. Torrey Club **74**: 398–402. S 1947.

Sanborn, Ethel I. & Doty, Maxwell S. The marine algae of the Coos Bay—Cape Arago region of Oregon. Oregon St. Monogr. Stud. Bot. **8**: 1–66. *pl. 1–4 + tables 1–4.* O 1944 [1947].

Williams, Louis G. & Blomquist, H. L. A collection of marine algae from Brazil. Bull. Torrey Club **74**: 383–397. *f. 1–3.* S 1947.

FUNGI AND LICHENS

Antikajian, Grace. *Rhizophydium chitinophilum.* Mycologia **39**: 612–616. *f. 1–20.* S 1947.

Des Abbayes, H. Contributions a l'étude des lichens des îles Hawaii: *Cladonia* récoltés en 1909–1910 par l'Abbé Faurie. Bull. Mus. Hist. Nat. [Paris] II. **19**: 105–117. *f. 1, 2.* Ja 1947.

Dolan, Desmond. A new anthracnose on melons [*Marssonia melonis* n. sp.]. Phytopathology **37**: 583–596. *f. 1–4 + tables 1–6.* Au 1947.

Drechsler, Charles. A *Basidiobolus* producing elongated secondary conidia with adhesive beaks. Bull. Torrey Club **74**: 403–413. *f. 1–22.* S 1947.

Dulaney, Eugene L. Penicillin production by the *Aspergillus nidulans* group. Mycologia **39**: 582–586. *tables 1, 2.* S 1947.

Dulaney, Eugene L. Some aspects of penicillin production by *Aspergillus nidulans.* Mycologia **39**: 570–581. *tables 1–4.* S 1947.

Evans, Alexander W. The *Cladoniae* of Vermont. Bryologist **50**: 221–246. S [O] 1947.

Hagen, Asbjörn. Uredineae from East Greenland. Uredineana **2**: 62–68. 1946.

Latham, Roy. *Cetraria islandica* (L.) Asch. on Long Island, N. Y. Bryologist **50**: 269, 270. S [O] 1947.

Lepage, Abbe Ernest. Les lichens, les mousses et les hépatiques du Québec. Nat. Canad. **74**: 93–101. Mr–Ap [Je] 1947; 225–240. Jl–Au [S]; 280–292. S–O.

Long, W. H. Studies in the Gasteromycetes XV. Notes on new or rare species of *Tylostoma.* Lloydia **10**: 115–135. *pl. 1–7.* Je [S] 1947.

Mains, E. B. New and interesting species of *Cordyceps.* Mycologia **39**: 535–545. *f. 1–3.* S 1947.

Pollack, Flora G. Two additions to the Fungi Imperfecti. Mycologia **39**: 617–621. *f. 1.* S 1947.

Räsänen, Veli. Lichenes novi. I. Ann. Bot. Soc. Zool.-Bot. Vanamo **20**^{3}: 1–34. 1944–45.

Rogers, Donald P. A new gymnocarpous heterobasidiomycete with gasteromycetous basidia. Mycologia **39**: 556–564. *f. 1.* S 1947.

Ruiz O., Manuel. Estudio de una neuva especie de levedura del género *Rhodotorula* Harrison aislada del néctar de las flores de *Martynia fragrans.* Anal. Inst. Biol. [Mexico] **18**: 25–41. *f. 1–8.* 1947.

Smith, Alexander H. North American species of *Mycena. i–xi,* 1–521. *pl. 1–98 + f. 1–56.* Ann Arbor. Univ. Mich. Press. 1947.

Smith, Alexander H. & Morse, Elizabeth E. The genus *Cantharellus* in the western United States. Mycologia **39**: 497–534. *f. 1–13.* S 1947.

Smith, Alexander H. & Walters, Maurice B. Notes on the genus *Armillaria.* Mycologia **39**: 622–625. *f. 1.* S 1947.

Thirumalachar, M. J. Species of the genera *Doassansia, Doassansiopsis* and *Buirillia* in India. Mycologia **39**: 602–611. *f. 1–9.* S 1947.

Waksman, Selman A. What is an antibiotic or an antibiotic substance? Mycologia **39**: 565–569. S 1947.

White, W. Lawrence & Downing, Mary H. The identity of "*Metarrhizium glutinosum.*" Mycologia **39**: 546–555. *f. 1, 2 + table* 1. S 1947.

BRYOPHYTES

Andrews, A. LeRoy. Studies in the Warnstorf *Sphagnum* Herbarium. IV. The group *Acutifolia* in South America. Bryologist **50**: 181–186. Je [Jl] 1947.

Bartram, Edwin B. New species and new combinations of Guatemalan mosses. II. Bryologist **50**: 202–208. Je [Jl] 1947.

Bartram, Edwin B. Okinawa mosses. Bryologist **50**: 158–165. *f. a–h.* Je [Jl] 1947.

Clark, Lois & Svihla, Ruth Dowell. *Frullania involuta.* Bryologist **50**: 271–275. *f. 1–27.* S [O] 1947.

Conard, Henry S. *Braunia secunda* in Texas. Bryologist **50**: 270, 271. S [O] 1947.

Erskine, J. S. Minute mosses of Windsor, Nova Scotia. Bryologist **50**: 276–278. S [O] 1947.

Fulford, Margaret. *Leucolejeunea clypeata*—its habit and structure. Bryologist **50**: 97–112. *f. 1–38.* Je [Jl] 1947.

Fulford, Margaret, Carroll, Gladys & Cobbe, Thomas. The response of *Leucolejeunea clypeata* to variations in the nutrient solution. Bryologist **50**: 113–146. *pl. 1–11 + f. 1–9 + tables 1–3.* Je [Jl] 1947.

Fulford, Margaret & Kersten, Harold. The reaction of *Leucolejeunea clypeata* to variations in dosage of soft X rays. Bryologist **50**: 147–156. *pl. 12.* Je [Jl] 1947.

Haring, Inez M. A check-list of the mosses of the state of Arizona. Bryologist **50**: 189–201. Je [Jl] 1947.

Harvill, A. M. Notes on the moss flora of Alaska. I. The mosses of Attu Island collected by Margaret Bell Howard and George B. Van Schaack. Bryologist **50**: 169–177. Je [Jl] 1947.

Kucyniak, James. Two Pottiaceae new to Quebec: *Phascum cuspidatum* var. *americanum* and *Astomum phascoides.* Bryologist **50**: 178–180. Je [Jl] 1947.

Messmer, Louis W. & Frye, T. C. The *Polytrichum juniperinum* group between South America and the United States. Bryologist **50**: 259–268. *f. A, B.* S [O] 1947.

Persson, Herman. Further notes on Alaskan-Yukon bryophytes. Bryologist **50**: 279–310. *f. 1, 2.* S[O] 1947.

Phillips, Edwin Allen. Notes on Borabora, Society Islands, and a small collection of mosses from Mt. Temanu. Bryologist **50**: 166, 167. Je [Jl] 1947.

Phillips, Edwin Allen. A small collection of mosses from Nasake Jima, south of Hiroshima, Honshu, Japan. Bryologist **50**: 168. Je [Jl] 1947.

Phillips, Edwin Allen. Two species of moss collected on Southern Samar, Philippine Islands. Bryologist **50**: 167. Je [Jl] 1947.

S[teere], W. C. Bryological collecting during World War II. Bryologist **50**: 156, 157. Je [Jl] 1947.

Steere, William Campbell. A consideration of the concept of genus in the Musci. Bryologist **50**: 247–258. S [O] 1947.

Welch, Winona H. *Fontinalis duthieae* (Dixon mss.) Sim. Bryologist **50**: 187, 188. Je [Jl] 1947.

Pteridophytes

(See also under Spermatophytes: **Jones**)

Ching, R. C. On natural classification of the family "Polypodiaceae." Sunyatsenia **5**: 201–268. *chart.* 1940.

Ching, R. C. On the genus *Gleichenia* Smith. Sunyatsenia **5**: 269–288. 1940.

Chou, Ruth Chen-Ying. *Lygodium flexuosum* var. *accidens*, a new climbing fern from Kweichow Province, China. Bull. Torrey Club **74**: 374–377. *f. 1, 2* + A–E. S 1947.

Chou, Ruth Chen-Ying & Bartlett, H. H. *Lycopodium Copelandianum*, a Sumatran clubmoss. Bull. Torrey Club **74**: 369–373. *f. A, B + 1–4.* S 1947.

Chrysler, M. A. & Edwards, J. L. The ferns of New Jersey. *i-vii, 1–201. front., f. 1–110 + maps 1–76.* New Brunswick [N.J.] 20 O 1947.

Copeland, E. B. Comment on natural classification of the family Polypodiaceae by R. C. Ching. Sunyatsenia **6**: 159–177. 1941.

Degener, Otto *et al.* Flora Hawaiiensis: New Illustrated Flora of the Hawaiian Islands. [*Adiantum hispidulum, Cyrtomium caryotideum* & *Neottopteris nidus.*] 3 lamina. *illustr.* Honolulu. 15 N 1946.

Hazen, H. H. Survey of ferns in a Maine mountain area. Am. Fern Jour. **37**: 79–84. J–S [O] 1947.

Holttum, R. E. A revised classification of leptosporangiate ferns. Jour. Linn. Soc. **53**: 123–158. 21 O 1947.

Maxon, William R. New ferns from the northern Andes. Contr. Gray Herb. **165**: 69–75. *pl. 4–6*. 6 O 1947.

Maxon, William R. Puerto Rican fern notes. Proc. Biol. Soc. Wash. **60**: 123–130. 9 O 1947.

Neidorf, Charles. Studio fern photography. Am. Fern Jour. **37**: 67–77. *pl. 3, 4*. Jl–S [O] 1947.

Taylor, T. M. C. New species and combinations in *Woodsia* section *Perrinia*. Am. Fern Jour. **37**: 84–88. Jl–S 1947.

Tryon, Alice F. Glandular prothallia of *Notholaena Standleyi*. Am. Fern Jour. **37**: 88, 89. *f. 1*. Jl–S 1947.

Wagner, Warren Herbert. Tree-climbing Gleichenias. Am. Fern Jour. **37**: 90–95. *pl. 5*. Jl–S 1947.

Weatherby, C. A. *Polypodium lepidopteris* and its relatives in Brazil. Contr. Gray Herb. **165**: 76–82. 6 O 1947.

Wherry, Edgar T. Our easternmost *Cheilanthes* species. Am. Fern Jour. **37**: 77–79. Jl–S [O] 1947.

SPERMATOPHYTES

(See also under Ecology: **Holdridge** et al)

Acosta Solis, M. Cinchonas del Ecuador. 1–271. *pl. 1–41 + map*. Quito. My 1946.

Aguilar, José Luis. Corrección de la sinonimia de la planta llamada vulgarmente aguacate. Revista Soc. Cub. Bot. **3**: 152–154. N–D 1946.

Akers, John. New species [of Cacti] from Peru. Cactus & Succ. Jour. **19**: 162, 163. *f. 109, 110*. O 1947.

Anderson, J. P. Flora of Alaska, and adjacent parts of Canada. Part VI. Crassulaceae to Fabaceae. Iowa St. Coll. Jour. Sci. **21**: 363–423. *pl. 24–30*. Jl 1947.

Anderson, W. A. New distributional records in Kentucky. Castanea **12**: 50–56. Je [Au] 1947.

Arsène, Brother Louis. Plants new to the Flora of the Islands of Saint-Pierre et Miquelon. Rhodora **49**: 237–255. 11 O 1947.

Atchison, Earlene. Studies in the Leguminosae. 1. Chromosome numbers in *Erythrina* L. Am. Jour. Bot. **34**: 407–414. *f. 1–32 + table 1*. O 1947.

Babcock, Ernest Brown. The genus *Crepis*—Part I—The taxonomy, phylogeny, distribution, and evolution of *Crepis*. Univ. Calif. Publ. Bot. **21**: *i–x*, 1–198. *pl. 1 + f. 1–11 + §§ A–D + tables 1–12*. 30 Je 1947. Part 2—Systematic treatment. **22**: *i–x*, 199–1030. *pl. 2–36 + f. 12 + 305 + tables 13–19*. 27 Au.

Bacigalupi, Rimo. A new combination in the genus *Telesonix*. Leafl. West. Bot. **5**: 71. 31 O 1947.

Bailey, L. H. The Gouane palm of Haiti. Contr. Gray Herb. **165**: 5–9. *pl. 1, 2 + f. 1–3*. 6 O 1947.

Barneby, R. C. Distributional notes and minor novelties. Leafl. West. Bot. **5**: 61–66. 31 O 1947.

Bean, R. C. *et al.* Reports on the flora of Massachusetts—IV. Rhodora **49**: 257–277. N 1947.

Beetle, A. A. Distribution of the native grasses of California. Hilgardia **17**: 309–357. Ap 1947.

Beetle, Alan Ackerman. *Scirpus.* N. Am. Flora **18:** 481–504. 29 O 1947.

Breitung, A. J. Catalogue of the vascular plants of central eastern Saskatchewan. Canad. Field-Nat. **61:** 71–100. My 1947.

Brown, J. R. *Adromischus cristatus.* (Haw.) Lam. Cactus & Succ. Jour. **19:** 92, 93. Je 1947.

Brown, William H. Useful plants of the Philippines. Volume 3. Repub. Philipp., Dept. Agr. & Comm. Tech. Bull. **10:** 1–507. *f. 1–170 + tables 1–80.* 1946.

Chin, T. C. & Youngken, H. W. The cytotaxonomy of *Rheum.* Am. Jour. Bot. **34:** 401–407. *f. 1–8 + table 1.* O 1947.

Cronquist, Arthur. *Chrysanthemum Balsamita* in Idaho. Leafl. West. Bot. **5:** 72. 31 O 1947.

Deam, Charles C., Yuncker, T. G. & Friesner, R. C. Indiana plant distribution records, VII. 1946. Proc. Ind. Acad. **56** (1947): 106–114. 1947.

Degener, Otto *et al.* Flora Hawaiiensis: New Illustrated Flora of the Hawaiian Islands. [Amaryllidaceae (desc. fam.), *Chamaesyce degeneri, Linaria canadensis* var. *texana, Arctium lappa* & *Cirsium lanceolatum.*] 5 lamina, *illustr.* Honolulu. 15 N 1946.

Dore, W. G. *Glyceria maxima* in Canada. Canad. Field-Nat. **61:** 174. S–O 1947.

Dutilly, Père **Artheme & Lapage,** Abbé **Ernest.** Coup d'oeil sur la flore subarctique du Québec, de la baie James au lac Mistassini [pars]. Nat. Canad. **74:** 66–78. Mr–Ap [Je] 1947. 207–224. Jl–Au [S]. 250–272. S–O [N].

Eastwood, Alice. Endemism in the flora of California. Contr. Gray Herb. **165:** 55–62. 6 O 1947.

Eastwood, Alice. Monoecious junipers in Modoc County, California. Leafl. West. Bot. **5:** 72. 31 O 1947.

Fassett, Norman C. *Veronica connata* Rafinesque. Jour. Wash. Acad. **37:** 353, 354. 15 O 1947.

Fernald, M. L. *Equisetum palustre,* example of careless bibliography and phytography. Rhodora **49:** 278–286. N 1947.

Fogg, John M. Some methods applied to a state flora survey. Contr. Gray Herb. **165:** 121–132. *f. 1–4.* 6 O 1947.

Foster, Robert C. Studies in the Iridaceae, IV. Contr. Gray Herb. **165:** 106–111. 6 O 1947.

Gates, F. C. Kansas botanical notes, 1946, including species new to the state. Trans. Kan. Acad. **50:** 72–74. Je 1947.

Goodspeed T. H. On the evolution of the genus *Nicotiana.* Proc. Nat. Acad. **33:** 158–171. Je 1947.

Groh, Herbert. Hackberry in and adjacent to the Province of Quebec. Canad. Field-Nat. **61:** 141, 142. Jl–Au [S] 1947.

Habeeb, Herbert. *Vicia sepium* in New Brunswick. Rhodora **49:** 288. N 1947.

Hawkes, Alex D. The epiphytic orchids of Florida. Am. Orchid Soc. Bull. **16:** 564, 565. *2 f.* 1 O 1947.

Heiser, Charles. *Asperugo* in California. Leafl. West. Bot. **5:** 71. 31 O 1947.

Hernández Xolocotzi, E. La *Sheelea Liebmanii* Becc. (Coyol real o corozo); su distribución y producción. Anal. Inst. Biol. [Mexico] **18:** 43–70. *f. 1–11 + maps 1–3 + tables 1–7.* 1947.

Hoover, Robert F. A new name in the genus *Senecio* [*pattersonensis*]. Leafl. West. Bot. **5:** 60. 31 O 1947.

Howard, Richard A. The use of DDT in the preparation of botanical specimens. Rhodora **49:** 286–288. N 1947.

Howell, John Thomas. Additional notes on the grass family in Marin County, California. Leafl. West. Bot. **5**: 69–71. 31 O 1947.

Howell, J. T. *Euphorbia prostrata* Ait. in California. Leafl. West. Bot. **5**: 72. 31 O 1947.

Howell, John Thomas. Further studies of broadleaf *Erodium*. Leafl. West. Bot. **5**: 67, 68. 31 O 1947.

Hull, Edwin D. *Penstemon gracilis* in Indiana. Rhodora **49**: 256. 11 O 1947.

Hutchinson, J. B. Notes on the classification and distribution of genera related to *Gossypium*. New Phytol. **46**: 123–141. Je 1947.

Johnston, Ivan M. *Astragalus* in Argentina, Bolivia and Chile. Jour. Arnold Arb. **27**: 336–374. 15 Jl 1947; 375–409. 15 O.

Jones, Clyde H. Additions to the revised catalogue of Ohio vascular plants Ohio Jour. Sci. **47**: 201–205. 1947.

Jovet, P. Aux confins des Rubiacées et des Longaniacées. Not. Syst. [Paris] **10**: 39–53. *f. 1, 2.* N 1941

Keck, David D. A new *Penstemon* [*Paysoniorum*] from Wyoming. Leafl. West. Bot. **5**: 57, 58. 31 O 1947.

Kobuski, Clarence E. Studies in the Theaceae, XVI. Bibliographical notes on the genus *Laplacea*. Jour. Arnold Arb. **28**: 435–438. 15 O 1947.

Krukoff, B. A. & Moldenke, H. N. Supplementary notes on American Menispermaceae—IV. Bull. Torrey Club **74**: 378–382. S 1947.

Lasser, Tobias. El género *Leitgebia* Eichl. Bol. Acad. Ci. Fís. Mat. Nat. [Caracas] **9**: 245–248. *1 f.* 1946.

Lasser, T. Plantae novae venezuelanae [*Beilschmiedia Roheiana*]. Bol. Acad. Ci. Fís. Mat. [Caracas] **10**: 193–195. *1 f.* 1946.

Li, Hui-Lin. Notes on the Asiatic flora. Jour. Arnold Arb. **28**: 442–444. 15 O 1947.

Lindsay, G. E. Cacti from San Pedro Nolasco Island. Des. Pl. Life **19**: 71–76. My 1947.

Lindsay, George. New cactus species from San Pedro Nolasco Island. Cactus & Succ. Jour. **19**: 151–154. *f. 99–103.* O 1047.

Lloyd, F. E. & Taylor, G. Some new species of *Utricularia*. Contr. Gray Herb. **165**: 82–90. *f. 1–5.* 6 0 1947.

Louis-Marie, Père. La taxonomie doit-elle s'expérimentaliser? Contr. Gray Herb. **165**: 112–131. 6 O 1947.

McClure, F. A. The genus *Bambusa* and some of its first-known species. Blumea Suppl. **3**: 90–112. *pl. 1–7.* 16 O 1946.

MacDaniels, L. H. A study of the Fe'i banana [*Musa Troglodytarum*] and its distribution with reference to Polynesian migrations. Bishop Mus. Bull. **190**: 1–56. *pl. 1–10 + f. 1–5.* 1 My 1947.

Martínez, Maximino. Los *Cupressus* de Mexico. Anal. Inst. Biol. [Mexico] **18**: 71–149. *f. 1–48.* 1947.

Merrill, E. D. The technical name of allspice. Contr. Gray Herb. **165**: 30–38. *f. 1.* 6 O 1947.

Merrill, E. D. & Sandwith, N. Y. On the identity of the genera *Cupulissa* Raf. and *Platolaria* Raf. Jour. Arnold Arb. **28**: 430–434. 15 O 1947.

Neal, Marie C. A *Manilkara* found on Oahu, Hawaii. Pacif. Sci. **1**: 243, 244. *1 f.* O 1947.

Ogden, E. C. *Potamogeton tennesseensis* new to the [Gray] Manual range. Rhodora **49**: 255, 256. 11 O 1947.

Palmer, Ernest J. Second supplement to the spontaneous flora of the Arnold Arboretum. Jour. Arnold Arb. **28**: 410–418. 15 O 1947.

Parodi, Lorenzo R. The Andean species of the genus *Stipa* allied to *Stipa obtusa*. Blumea Suppl. **3**: 63–70. *f. 1*. 16 O 1946.

Peck, Morton E. Certain Oregon saxifrages. Leafl. West. Bot. **5**: 58–60. 31 O 1947.

Pérez Moreau, Román A. Reseña botánica sobre los parques nacionales Nahuel Haupi, Los Alerces y Lanín. Anal. Mus. Patag. **1**(1945): 253–276. *pl. 1–43*. 1946.

Pichon, M. Le genre *Combretodendron* et les Lécythidacées. Not. Syst. [Paris] **12**: 192–197. F 1946.

Pichon, M. Sur les Alismatacées et les Butomacées [includes *Albidella*, gen. nov.,—Cuba, Br. Hond.; key to gen. of redefined Alismaceae]. Not. Syst. [Paris] **12**: 170–183. F 1946.

Pichon, M. Sur les Commélinacées [Keys to tribes and genera; also 3 new genera in Western Hemisphere]. Not. Syst. [Paris] **12**: 217–242. F 1946.

Polunin, Nicholas. Additions to the flora of Southampton and Mansel Islands, Hudson Bay. Contr. Gray Herb. **165**: 94–105. 6 O 1947.

Ponce de León, Antonio. Joyas de la flora cubana. El copey (*Clusia rosea* Jacq.). Revista Soc. Cub. Bot. **3**: 143. *1 pl.* N–D 1946

Quisumbing, Eduardo. Studies on *Phalaenopsis*, III. Philipp. Jour. Sci. **77**: 1–18. *pl. 1–5*. My 1947.

Rehder, Alfred. Notes on some cultivated trees and shrubs, VI. Jour. Arnold Arb. **28**: 445, 446. 15 O 1947.

Rehder, Alfred. Two new forms of *Rhododendron roseum*. Contr. Gray. Herb. **165**: 9-11. 6 O 1947.

Roland-Gosselin, R. Are the species of *Rhipsalis* discovered in Africa indigenous? Des. Pl. Life **19**: 121-123, 124. O 1947.

Rollins, Reed C. Generic revisions in the Cruciferae: *Sibara*. Contr. Gray Herb. **165**: 133–143. 6 O 1947.

St. John, Harold. *Pleomele Fernaldii* (Liliaceae), a new species from the Hawaiian Islands. Hawaiian plant studies 16. Contr. Gray Herb. **165**: 39–42. *pl. 3*. 6 O 1947.

Sandwith, N. Y. Two new leguminous trees of British Guiana. Contr. Gray Herb. **165**: 25–29. 6 O 1947.

Schnee, L. *Stenoptera Rohlii;* una especie nueva de las Orquideas. Bol. Acad. Ci Fis. Mat. Nat. [Caracas] **9**: 249–252. *2 f.* 1946.

Schweinfurth, Charles. A new *Pachyphyllum* from Peru. Am. Orchid Soc. Bull. **16**: 564, 565. *f. 1–4*. 1 O 1947

Schweinfurth, Charles. A novel *Dichaea* from Peru. Am. Orchid Soc. Bull. **16**: 614, 615. *f. 1–7*. 1 N 1947.

Shanks, R. E. & Sharp, A. J. Summer keys to the trees of eastern Tennessee. Jour. Tenn. Acad. **22**: 114–133. Ap 1947.

Smith, Lyman B. & Schubert, Bernice G. Some Mexican begonias. Contr. Gray Herb. **165**: 90–94. *f. 1*. 6 O 1947.

Standley, Paul C. & Steyermark, Julian A. Studies of Central American plants—VII. Publ. Field Mus. Nat. Hist. Bot. **23**: 195–265. *pl. 5*. 22 O 1947.

Stearn, William T. The nomenclature and synonymy of *Tofieldia calyculata* and *T. pusilla*. Jour. Linn. Soc. **53**: 194–204. *f. 1–33*. 21 O 1947.

Stebbins, G. Ledyard. The origin of the complex of *Bromus carinatus* and its phytogeographic implications. Contr. Gray Herb. **165**: 42–55. *f. 1*. 6 O 1947.

Steenis, C. G. J. van. Notes on a number of New Guinean species. Jour. Arnold Arb. **28**: 419–423. 15 O 1947.

Svenson, Henry Knute. Scirpeae. N. Am. Flora **18**: 479. 29 O 1947.

Turner, George H. Alpine plants in the Pigeon Lake district of Alberta. Canad. Field-Nat. **61**: 126. Jl–Au [8] 1947.

Uitewaal, A. J. A. *Haworthia guttata* Uitewaal spec. nov. Des. Pl. Life **19**: 101. *illust.* 12 S 1947.

Uitewaal, A. J. A. Some little known Haworthias, *Haworthia fouchei* Poelln. Des. Pl. Life **19**: 53. Ap 1947. *Haworthia truncata* forma *crassa* Poelln. 78, 79. My.

White, Stephen S. New plants from northeastern Sonora, Mexico, and notes on extensions of range. Jour. Arnold Arb. **28**: 439–441. 15 O 1947.

ECOLOGY AND PLANT GEOGRAPHY

Dexter, Ralph W. The marine communities of a tidal inlet at Cape Ann, Massachusetts: A study in bio-ecology. Ecol. Monogr. **17**: *261–294. f. 1–17 + table 1–11.* Jl [O] 1947.

Dirks-Edmunds, Jane C. A comparison of biotic communities of the cedar-hemlock and oak-hickory associations. Ecol. Monogr. **17**: 235–260. *f. 1–10 + tables 1, 2.* Jl [O] 1947.

Farmer, C. M. Ecological factors in the Pike County pocosin. Jour. Ala. Acad. **18**: 57. D 1946.

Holdridge, L. R. *et al.* The forests of western and central Ecuador. 1–134. *85 photos + 2 maps.* U. S. Dept. Agr. Forest Service. Je 1947 [Offset].

Johnson, Frederick & Raup, Hugh M. Grassy Island: Archaeological and botanical investigations of an Indian site in the Taunton River, Massachusetts. Pap. Peabody Found. Arch. **1**: *i-viii*, 1–68. *pl. 1–3 + f. 1–9.* 1947.

Sharp, Aaron J. Informe preliminar sobre algunos estudios fitogeográficos efectuados en México y Guatemala. Revista Soc. Mex. Hist. Nat. **7**: 35–39. *f. 1–5.* D 1946.

Woodson, Robert E. Notes on the "historical factor" in plant geography. Contr. Gray Herb. **165**: 12–25. *f. 1, 2.* 6 O 1947.

PHYTOPATHOLOGY

(See also under Fungi: **Dolan**)

Foster, H. H. The control of cabbage downy mildew through the use of sprays. Phytopathology **37**: 712–720. *tables 1–4.* O 1947.

Gruenhagen, R. H., Riker, A. J. & Richards, C. Audrey. Burn blight of jack and red pine following spittle insect attack. Phytopathology **37**: 757–772. *f. 1–4 + tables 1–3.* O 1947.

Henry, B. W. & Riker, A. J. Wound infection of oak trees with *Chalara quercina* and its distribution within the host. Phytopathology **37**: 735–743. *f. 1 + tables 1–3.* O 1947.

Leach, L. D. Growth rates of host and pathogens as factors determining the severity of preemergence damping-off. Jour. Agr. Res. **75**: 161–179. *f. 1–6.* 15 S 1947.

Marchionatto, Juan B. Nota sobre *Balansia claviceps*, hongo parásito de las gramíneas. Revista Argent. Agron. **14**: 175, 176. *1 f.* Je 1947.

Rodenhiser, H. A. & Hurd-Karrer, Annie M. Evidence of fusion bodies from urediospore germ tubes of cereal rusts on nutrient-solution agar. Phytopathology **37**: 744–756. *f. 1–5 + table 1.* O 1947.

Sprague, Roderick. Septoria disease of Gramineae in western United States. Oregon St. Monogr. Stud. Bot. **6**: 1–151. *f. 1–18.* D 1944.

Stark, Frank L., & Lear, Bert. Miscellaneous greenhouse tests with various soil fumigants for the control of fungi and nematodes. Phytopathology **37**: 698–711. O 1947.

Thirumalachar, M. J. & Dickson, James G. Chlamydospore germination and artificial culture of *Ustilago striiformis* from timothy and bluegrass. Phytopathology **37**: 730–734. *f. 1, 2.* O 1947.

Weimer, J. L. Resistance of *Lathyrus* spp. and *Pisum* spp. to *Ascochyta pinodella* and *Mycosphaerella pinodes*. Jour. Agr. Res. **75**: 181–190. *f. 1–3.* 15 S 1947.

Wilson, E. E. The branch wilt of Persian walnut trees and its cause. Hilgardia **17**: 413–436. *pl. 1–4 + f. 1–4 tables 1, 2.* Au 1947.

Wolf, Frederick A. Tobacco downy mildew, endemic to Texas and Mexico. Phytopathology **37**: 721–729. *f. 1, 2.* O 1947.

MORPHOLOGY

(including anatomy and cytology in part)

(See also under Spermatophytes: **Atchison**)

Artschwager, Ernst. Pollen degeneration in male-sterile sugar beets with special reference to the tapetal plasmodium. Jour. Agr. Res. **75**: 191–197. *pl. 1–7.* O 1947.

Barton, Lela & Thornton, Norwood C. Germination and sex population studies of *Ilex opaca* Ait. Contr. Boyce Thompson Inst. **14**: 405–410. *tables 1–3.* Jl–S [N] 1947.

Boke, Norman H. Development of the adult shoot apex and floral initiation in *Vinca rosea L.* Am. Jour. Bot. **34**: 433–439. *f. 1–12.* O 1947.

Buchholz, J. T. Methods in the preparation of chromosomes and other parts of cells for examination with an electron microscope. Am. Jour. Bot. **34**: 445–454. *f. 1–22.* O 1947.

Garber, E. D. The pachytene chromosome of *Sorghum nitrans*. Jour. Hered. **38**: 251, 252. *f. 5.* Au [O] 1947.

Gosselin, L. A. Étude sur les noyaux interphasiques et quiescents. II. Revue d'Oka **21**: 70–87. Mr–Ap 1947.

Joshi, A. C. Floral histogenesis and carpel morphology. Jour. Indian Bot. Soc. **26**: 63–74. F 1947.

King, Gladys S. Peripheral deposits of citrus fruit vesicles stained by oil-soluble dyes. Am. Jour. Bot. **34**: 427–431. *f. 1–3.* O 1947.

Nielsen, Etlar L. Macrosporogenesis and fertilization in *Bromus inermis*. Am. Jour. Bot. **34**: 431–433. *f. 1–7.* O 1947.

Rick, C. M. Partial suppression of hair development indirectly affecting fruitfulness and the proportion of cross-pollination in a tomato mutant. Am. Nat. **81**: 185–202. My 1947.

Schnee, L. Ramifications in *Alsophila caracasana*. Bol. Acad. Ci. Fis. Mat. Nat. [Caracas] **10**: 197–210. *f. 1–25.* 1946.

Sharman B. C. The biology and developmental morphology of the shoot apex in the Gramineae. New Phytol. **46**: 20–34. *pl. 1–4.* Je 1947.

Smith, Frank H. Floral anatomy of the Santalaceae and some related forms. Oregon St. Monogr. Stud. Bot. **5**: 1–93. *pl. 1–15.* S 1942

Snow, Mary & Snow R. On the determination of leaves. New Phytol. **46**: 5–19. *f. 1–10* Je 1947.

GENETICS
(including cytogenetics)

Karper, R. E. & Quinby, K. R. The inheritance of callus formation and seed shedding in *Sorghum*. Jour. Hered. **38**: 211–214. *f. 5, 6.* Jl [S] 1947.

Langham, D. G. Genetics of *Sesame* IV. Some genetic variations in the color of the sesame flower. Jour. Hered. **38**: 211–224. *f. 9, 10.* Jl [S] 1947.

Lesley, J. W. & Lesley, Margaret Mann. Flesh color in hybrids of tomato. Jour. Hered. **38**: 245–251. *tables 1–3.* Au [O] 1947.

Mehlquist, G. A. L. A genetic and cytological study of certain orchidaceous genera with particular reference to those in which appreciable breeding work has already been done. Am. Orchid Soc. Bull. **16**: 330–333. 6 Je 1947.

White, O. E. & Bowden, W. M. Oriental and American bittersweet hybrids. Jour. Hered. **38**: 125–127. *f. 11.* Ap 1947.

PLANT PHYSIOLOGY

(See also under Taxonomy: Bryophytes: **Fulford, Carroll & Cobbe; Fulford & Kersten**)

Benson, A. & Calvin, M. The dark reductions of photosynthesis. Science **105**: 648, 649. 20 Je 1947.

Borthwick, H. A. Day length and flowering. Yearb. U. S. Dept. Agr. **1943–1947**: 273–283. 1947.

Dorland, Robert E. & Went, F. W. Plant growth under controlled conditions. VIII. Growth and fruiting of the Chili pepper *(Capsicum annuum)*. Am. Jour. Bot. **34**: 393–401. *f. 1–13 + tables 1–4.* O 1947.

Dustin, J. Supplement [to colchicine bibliography]. Lloydia **10**: 106–114. Je [S] 1947.

Eigsti, O. J. Colchicine bibliography. Lloydia **10**: 65–105. Je [S] 1947.

Gray, W. D. & Martin, G. W. The growth of fungi on asphalt-treated paper. Mycologia **39**: 587–601. *f. 1–7 + tables 1–6.* S 1947.

Hildebrandt, Albert C. & Riker, A. J. Influence of some growth-regulating substances on sunflower and tobacco tissue in vitro. Am. Jour. Bot. **34**: 421–427. *f. 1–12 + table 1.* O 1947.

Jacobson, Louis & Overstreet, Roy. A study of the mechanism of ion absorption by plant roots using radioactive elements. Am. Jour. Bot. **34**: 415–420. *f. 1–3 + table 1.* O 1947.

Kavanagh, Frederick. Antiluminescent activity of antibacterial substances. Bull. Torrey Club **74**: 414–425. *tables 1–3.* S 1947.

Robbins, W. J., Kavanagh, F. & Hervey, A. Antibiotic substances from Basidiomycetes. I–II. Proc. Nat. Acad. **33**: 171–182. Je 1947.

Roca, Juan. Actividad proteolítica de *Euphorbia prostrata* Ait., y *Eurphorbia peplus*, L. Anal. Inst. Biol. [Mexico] **28**: 7–14. *f. 8.* 1947.

Sparrow, A. H. & Hammond, Marian R. Cytological evidence for the transfer of desoxyribose nucleic acid from nucleus to cytoplasm in certain plant cells. Am. Jour. Bot. **34**: 439–445. *f. 1–12 + table 1.* O 1947.

Steinberg, Robert A. Growth responses of tobacco seedlings in aseptic culture to diffusates of some common soil bacteria. Jour. Agr. Res. **75**: 199–206. *f. 1–4 + tables 1, 2.* O 1947.